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FINAL REPORT

DEVELOPMENT OF GUIDELINES FOR HARVESTING ECHINACEA ANGUSTIFOLIA ROOTS

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Interim Report

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Development of Guidelines for Harvesting *Echinacea Angustifolia* Roots

March 20, 2000

By

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Abstract

Echinacea Angustifolia has a deep-growing fragile tap root which is difficult to harvest. Eight manual digs and mechanical harvesting trials were conducted at a site near Hearne in southern Saskatchewan. The site had silt clay, clay loam and sandy loam soil. Three-year-old and two-year-old plants were studied at the site. Two manual digs were conducted at a second site just west of Saskatoon. The site had loam soil. Three-year-old plants were studied at the site. The manual digs on the three-year-old plants indicated that 64%, 78% and 92% of the roots in the top 540 mm could be collected using a digging depth of 270 mm, 360 mm and 450 mm, respectively. The manual digs on the two-year-old plants indicated that 90% of the available roots could be collected using a digging depth of 270 mm. Horizontally the roots were concentrated in a region extending 150 mm on either side of the row. The Bartschi FOBRO Super HD Lifter/Shaker and the Weening Brothers Manufacturing, Ginsenger harvesters were tested. Harvesting in silt clay and clay loam soil was difficult for both harvesters. The Ginsenger satisfactorily harvested the roots of two-year-old plants from sandy loam soil.

Executive Summary

A major obstacle to the development of Echinacea root production in Saskatchewan was the availability of harvesting equipment. The dominant variety of Echinacea in Saskatchewan was *E. angustifolia*. This variety has a deep-growing fragile tap root which was difficult to harvest. A survey of commercial root harvesters indicated that commercial harvesters exist for many root crops including potato, carrot and ginseng. This investigation also indicated that a commercial harvester for *E. angustifolia* roots did not exist. Recommendations for harvesting width and depth based on soil type and plant age also do not exist. It was anticipated that an existing commercial root harvester could be modified for harvesting *E. angustifolia* roots. The objectives of this project were to select a suitable commercial root harvester, to test the harvester during one harvesting season and to provide recommendations to growers for harvesting *E. angustifolia* roots.

Visits were made by Mr. Victor Taylor, a Saskatchewan Echinacea grower, and Mr. Myles Bantle, an engineer, to Washington and Oregon between August 24 and August 29 and to southern Ontario and Wisconsin between August 31 and September 5. The visits were to evaluate a wide range of existing commercial root harvesting equipment. The visits included meetings with five equipment suppliers, a meeting with one Echinacea root wholesaler, attendance at a nursery trade show and numerous farm visits. Four of the equipment suppliers provided one day tours of their equipment.

The farms visited varied in the level of production sophistication. The most sophisticated farm was a farm in Washington that produced 1200 acres of carrots and 400 acres of onions. This farm had very integrated and high-capacity production methods. The fields were level. The crops were grown in carefully shaped and perfectly straight raised beds. The area was a desert and irrigation provided most of the crops' water requirements. The plant tops were precisely removed prior to harvesting using a rotary flail followed by a specialized crowner. The crop was harvested using a high-capacity fully-automatic harvester that loaded the crop into semi-trailers for transport to a processor. The other farms visited were not as sophisticated but all used mechanization and an integrated systems approach to planting, weeding and harvesting. Saskatchewan *E. angustifolia* growers will achieve more effective production by using equipment adapted to *E. angustifolia* and by integrating planting, weeding and harvesting.

During the farm visits, three root harvesters, each manufactured by a different company, were observed operating in the field: AMAC Model G2, Bartschi FOBRO Super HD Lifter/Shaker and Weening Brothers Manufacturing Ginsenger. All three harvesters were operated in sandy soils. Many other non-operating harvesters were also observed. The AMAC Model G2 was observed in Washington harvesting carrots. The harvester was a high-capacity automatic full feature harvester. The primary digging tool was a row of carrot pins that can be rotated to adjust the digging depth. The advantage of the carrot pins was that if they caught the subsoil and bent they could be easily replaced. The harvester features permitted effective soil, stone and trash removal prior to automatic loading into a truck. A used older model AMAC harvester cost $34,000. This harvester was considered too expensive for Saskatchewan Echinacea growers. The Bartschi FOBRO Super HD Lifter/Shaker was operated in a fallow field at a Washington tree nursery. The Bartschi FOBRO Super HD Lifter/Shaker was the smallest harvester and the only harvester which attached to the tractor using a three-point hitch. The primary digging tool was an oscillating under-cutter-blade. The harvester lifted the roots to the soil surface where the roots were manually collected. This

harvester was the only one that during the tours was reported by a farmer to be operated in clay soils. The design and construction of the harvester indicated that it may achieve the deepest digging depth of the three harvesters observed operating. A new Bartschi FOBRO Super HD Lifter/Shaker costs $17,000 and was one of the least expensive new harvesters. Unfortunately, the supplier did not sell used-harvesters. The Weening Brothers Manufacturing Ginsenger was observed harvesting *E. purpurea* in southern Ontario. Another harvester, the Gallenberg Equipment, Ginseng Digger was very similar to the Weening Brothers Manufacturing, Ginsenger. Both had an under-cutter-blade as the primary digging tool and both used a digging chain with mechanical or hydraulic agitation. These harvesters dropped the roots onto the soil surface. Manual collection was required. Harvesters were available with additional features for soil, stone and trash removal and automatic truck loading from both manufacturers. The depressed ginseng market made used harvesters readily available. Used harvesters cost about $10,000.

The vertical and horizontal distribution of *E. Angustifolia* roots was an important criterion for selection and operation of mechanical harvesting equipment. Manual digs were undertaken at Blue Hills Herb Farm Inc. located near Hearne, Saskatchewan and the farm of Wendy James and Ron Gillies located west of Saskatoon, Saskatchewan. Manual digs were made on two-year-old and three-year-old plants, transplants and direct-seeded plants and plants grown in clay loam, silt clay, sandy loam and loam soil. Two replicates were made for each category.

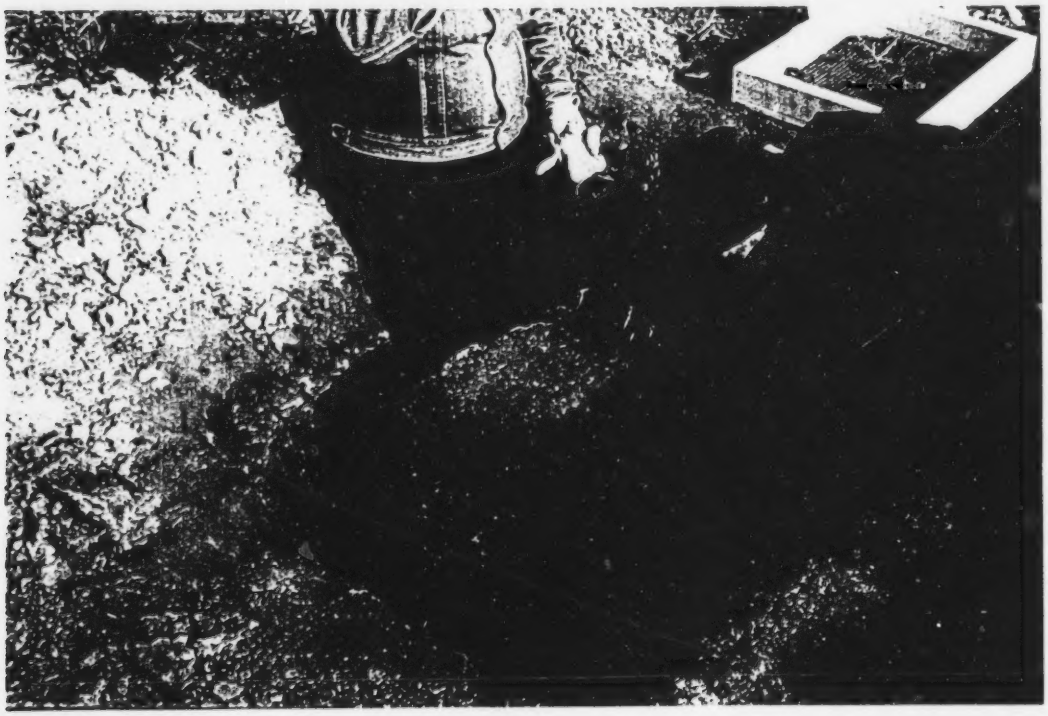

Photo 1 Manual Dig

The vertical dry-weight root distribution of three-year-old plants was not affected by the site or the soil type. Manual digs indicated that: 64% of the dry weight of roots in the top 540 mm could be collected with a digging depth of 270 mm, 78% of the dry weight of roots in the top 540 mm could be collected with a digging depth of 360 mm and 92% of the dry weight of roots in the top 540 mm could be collected with a digging depth of 450 mm. The roots extended below 540 mm however they were mostly smaller main tap roots with few laterals. Most existing commercial root harvesters can dig 360 mm deep with little or no modification. These harvesters will harvest nearly 80% of the total dry weight of roots in the top 540 mm.

The vertical dry-weight root distribution of two-year-old plants was not affected by the planting method, i.e., transplanted or direct-seeded. Manual digs indicated that below 360 mm, the roots were judged too small for mechanical harvesting. The manual digs also indicated that: 72% of the dry weight of roots could be collected with a digging depth of 180 mm and 90% of the dry weight of roots could be collected with a digging depth of 270 mm. Existing commercial root harvesters will harvest 100% of the total dry weight of roots available.

The manual digs indicated a mean total dry root weight of 80.8 grams per 300 mm of row in the top 360 mm for three-year-old transplanted plants and a mean total dry root weight of 66.8 grams per 300 mm of row in the top 360 mm of two-year-old direct-seeded plants. The dry root weight of the two-year-old direct-seeded plants was considered comparable to the dry root weight of the three-year-old transplanted plants based on the same length along the row. The roots of the three-year-old transplanted plants were larger than the roots of the two-year-old direct-seeded plants but the two-year-old direct-seeded plants were more densely seeded along the row.

The manual digs extended 425 mm on either side of the row. On occasion the roots were distributed horizontally across the manual dig but most often the roots were concentrated in a region 150 mm either side of the row.

The Bartschi FOBRO Super HD Lifter/Shaker and the Weening Brothers Manufacturing, Ginsenger harvesters were rented and tested at Blue Hills Herb Farm Inc. The FOBRO was tested in three-year-old plants in clay silt and clay loam soil. The Ginsenger was tested in three-year-old plants in clay silt and clay loam soil and in two-year-old plants in sandy loam soil. Neither harvester had the capacity to load the roots. The farmers walked behind the harvesters and collected the roots on the soil surface. After the farmers removed the roots on the soil surface, manual digs were conducted to assess the weight of roots dug by the harvester but buried below the soil surface. This root was deemed harvested but uncollectible.

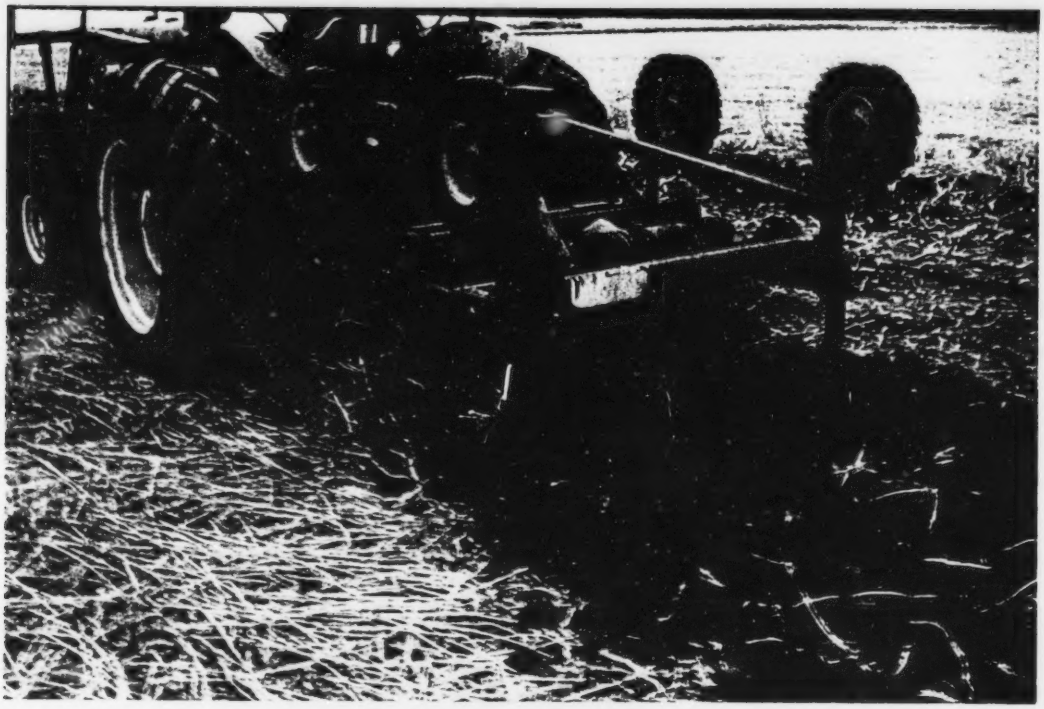

Photo 2 Bartschi FOBRO Super HD Lifter/Shaker

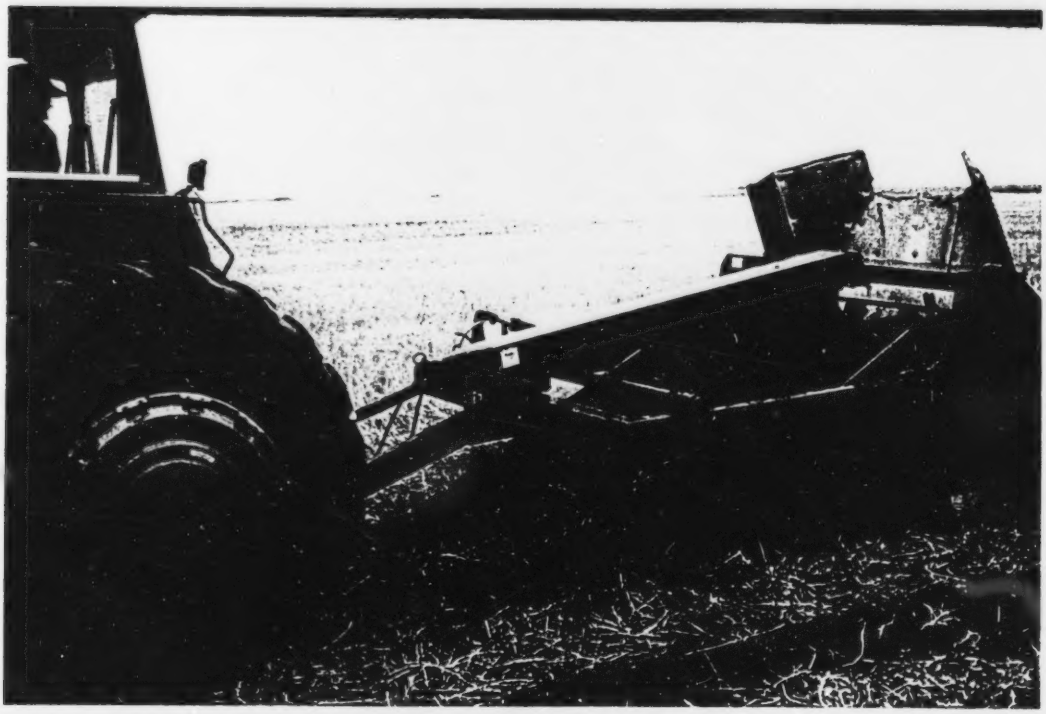

Photo 3 Weening Brothers Manufacturing, Ginsenger

Harvesting in silt clay and clay loam soil was difficult for the FOBRO and the Ginsenger. The soil broke into large clods. Some root fragments were trapped in the clods. The clods restricted the soil from dropping through the digging chain of the Ginsenger and restricted the separation of the root fragments from the soil. The clods restricted the FOBRO's ability to sift the root fragments from the soil. Adjustment of the FOBRO for optimum harvesting caused the FOBRO to work so aggressively that it jerked the tractor back and forth. Manual digs performed after mechanical harvesting indicated that with the FOBRO, 29% of the root harvested was uncollectible and with the Ginsenger 13% of the root harvested was uncollectible. The mechanical harvesting trials indicated that Saskatchewan *E. Angustifolia* growers should avoid silt clay and clay loam soils. The Ginsenger was tested in sandy loam soil on the two-year-old transplanted plants. Soil clods were not a problem. The Ginsenger placed the roots on the soil surface and left the plant root system nearly intact. Manual digs performed after mechanical harvesting with the Ginsenger indicated 6% of the root harvested was uncollectible. The soil profile was not significantly disturbed by the harvesting operation. The Ginsenger satisfactorily harvested the roots of two-year-old plants from sandy loam soil.

Acknowledgements

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Table of Contents

1. Background		1
2. Objectives		3
3. Experimental Methods		5
3.1 Experimental Methods - Visits to Root Harvester Suppliers		6
3.2 Experimental Methods - Root Distribution		7
3.2.1 Manual Digs		7
3.2.2 Root Washing		9
3.2.3 Root Drying		10
3.2.4 Soil Sample Analysis		10
3.3 Experimental Methods - Mechanical Harvester Evaluation		10
4. Observations		13
4.1 Observations - Visits to Root Harvester Suppliers		14
4.2 Observations - Root Distribution		20
4.3 Observations - Mechanical Harvester Evaluation		29
5. Conclusions		34
6. Future Development		37
7. Communication of Results		40
Appendix A	Manual Digs Test Procedure	42
Appendix B	Root Washing Test Procedure	47
Appendix C	Soil Sample Analysis Procedure	51
Appendix D	Mechanical Harvester Evaluation Test Procedure	55
Appendix E	Travel Observations	60
Appendix F	Harvester Brochures	72
Appendix G	Observations and Results from Manual Digs	90
Appendix H	Observations and Results from Mechanical Harvesting Trials	111
Appendix I	'Looking for Root Digging Equipment?'	120
Appendix J	'Mechanical Harvesting of Echinacea Roots'	124

Chapter 1

Background

A major obstacle to the development of Echinacea root production in Saskatchewan was the availability of harvesting equipment. The dominant variety of Echinacea in Saskatchewan was *E. angustifolia*. This variety has a deep-growing fragile tap root which was difficult to harvest. Most of the cultivated Echinacea in North America was *E. purpurea*. This variety had a fibrous root and was reported to be easier to harvest than *E. angustifolia*.

A survey of commercial root harvesters indicated that a variety of harvesters were available. The cost and capabilities of these harvesters varied. The cost varied between $16,000 and $93,000. Some of the harvesters were capable of topping, digging and loading the crop while others only dug the crop. None of these harvesters were specifically designed for *E. angustifolia* and it was unclear which of these harvesters was best suited for Saskatchewan *E. angustifolia* growers. Further, *E. angustifolia* growers, including local growers, who had harvesting experience, were secretive of their harvesting methods. A major obstacle to the development of *E. angustifolia* root production in Saskatchewan was the availability of harvesting equipment and recommendations for harvesting width and depth based on soil type and plant age. Further, it was anticipated that an emerging market for fresh roots would require timely high-volume harvesting methods.

Chapter 2

Objectives

A survey of commercial root harvesters indicated that commercial harvesters exist for many root crops including potato, carrot and ginseng. This investigation also indicated that a commercial harvester for *E. angustifolia* roots did not exist. The deep-growing fragile tap root of *E. angustifolia* made it difficult to harvest. It was anticipated that an existing commercial root harvester could be modified for harvesting *E. angustifolia* roots. The objectives of this project were to select a suitable commercial root harvester, to test the harvester during one harvesting season and to provide recommendations to growers for harvesting *E. angustifolia* roots.

Chapter 3

Experimental Methods

3.1 Experimental Methods - Visits to Root Harvester Suppliers

Visits were made by Mr. Victor Taylor, a Saskatchewan Echinacea grower, and Mr. Myles Bantle, an engineer, to Washington and Oregon between August 24 and August 29 and to southern Ontario and Wisconsin between August 31 and September 5. The visits were to evaluate a wide range of existing commercial root harvesting equipment. The visits included meetings with five equipment suppliers, a meeting with one Echinacea root wholesaler, attendance at a nursery trade show and numerous farm visits. Four of the equipment suppliers provided one day tours of their equipment. Table 3.1 lists the primary travel contacts.

Date of Visit	Contact
August 25, 1999	Mr. Bob Merrell KPR Incorporated P.O. Box 608, 375 West Avenue "D" WENDELL, IDAHO 83355-0608 Tel. (208) 536-6601
August 26, 1999	Mr. Beat Hauenstein Bartschi-FOBRO Dorf 1, Postfach 1 CH-6152 HUSWIL Switzerland Tel. 011 41 41 988-2121
September 1, 1999	Mr. Fred Weening Weening Brothers Manufacturing Inc. Wist Road, R.R. #1 KETTLEBY ONTARIO L0G 1J0 Tel. (905) 775-3839
September 3, 1999	Mr. Rueben Hintz Gallenberg Equipment, Inc. W9112 Cherry Rd. ANTIGO WI 54409 Tel. (715) 623-3754

Table 3.1 Primary Travel Contacts

3.2 Experimental Methods - Root Distribution

E. Angustifolia has a deep-growing tap root. The vertical and horizontal distribution of *E. Angustifolia* roots was an important criterion for selection and operation of mechanical harvesting equipment. Manual digs were undertaken at Blue Hills Herb Farm Inc. located near Hearne, Saskatchewan and the farm of Wendy James and Ron Gillies located west of Saskatoon, Saskatchewan. The manually harvested roots were washed and dried at the Department of Agricultural and Bioresource Engineering, University of Saskatchewan.

3.2.1 Manual Digs

Manual digs were made on two-year-old and three-year-old plants, transplants and direct-seeded plants and plants grown in clay loam, silt clay, sandy loam and loam soil. Two replicates were made for each category. Table 3.2 lists the manual dig categories.

Site	Plant Age (years)	Planting Method	Soil Type
Blue Hills Herb Farm Inc.	3	transplant	silt clay & clay loam
Blue Hills Herb Farm Inc.	3	transplant	sandy loam
Blue Hills Herb Farm Inc.	2	transplant	sandy loam
Blue Hills Herb Farm Inc.	2	direct-seeded	sandy loam
Farm of Wendy James and Ron Gillies	3	transplant	loam

Table 3.2 Manual Dig Categories

The plants in each category were in a single field. At Blue Hills Herb Farm Inc. all of the fields had a small elevation change. One manual dig was made in a higher area of the field while the second manual dig was made in a lower area of the field. The portion of a row selected for a manual dig had healthy plants with no unusual gaps between the plants. At the farm of Wendy James and Ron Gillies the field was level and only one row was available for manual digs. The two locations selected for manual digs were judged to have the least disturbance from the prior mechanical harvesting. Since the plant tops were removed, it was not possible to ensure the plants were healthy with no unusual gaps between the plants.

A rectangular area 850 mm by 300 mm was marked at each digging location. The 850 mm sides were oriented perpendicular to the row and centred on the row. In the rectangular

area, pruning shears was used to remove the tops of the plants at the soil surface. Using shovels, the soil was excavated around the perimeter of the rectangular area to a depth of 540 mm in three-year-old plants and 360 mm in two-year-old plants. Once the perimeter of the rectangular area was excavated, a rectangular box of soil slightly larger than 850 mm by 300 mm and 540 mm high in three-year-old plants and 360 mm high in two-year-old plants, was left. The soil was stable and the vertical sides of the box did not crumble. Using a knife, the top 90 mm of the rectangular box was shaved to exactly 850 mm by 300 mm. A wood frame 90 mm high with inside dimensions of 850 mm by 300 mm was pushed onto the top of the rectangular box of soil until the surface formed by the top edges of the frame coincided with the top surface of the rectangular box of soil. Using the bottom edges of the frame as a guide, a knife cut was made horizontally which severed the top 90 mm of soil from the rectangular box of soil. The wood frame was removed. The slice of soil was removed in pieces and placed in a sifting box. The horizontal distribution of roots was visually observed and recorded. Most of the root fragments were recovered as the soil was placed in the sifting box. The remaining root fragments were sifted from the soil. The sifting box had a wire mesh screen with an opening 11 mm square. The obvious soil attached to the root fragments was rubbed off. The root fragments were collected in a labelled zip lock plastic bag. The bag was 270 mm by 280 mm. The excess air in the bag was forced out of the bag. The bag was closed and placed in a picnic cooler. In three-year-old plants, five additional slices of soil, each 90 mm thick, were removed and the root fragments were collected into labelled zip lock plastic bags. In two-year-old plants, three additional slices of soil, each 90 mm thick, were removed and the root fragments were collected into labelled zip lock plastic bags.

Photo 4 Manual Dig

The procedure followed to cut the slices of soil changed as the samples were collected. Initially, the bottom edge of the wood frame was used as a guide for cutting the slices of soil. Later, the bottom edge of the frame was used to mark the bottom edge of the slice of soil and removed prior to cutting. Still later, a wooden peg 850 mm long that was graduated in 90 mm increments was vertically installed adjacent to one side of the rectangular box of soil that was 300 mm in length. The peg was driven into the soil at the base of the peg. A combination of the peg, a wood frame and a tape measure was used to mark and cut the 90 mm thick slices of soil.

A sample of soil was collected from the first slice of soil. The sample was stored in a labelled zip lock plastic bag. The bag was 180 mm by 200 mm.

The root fragment samples and the soil samples were stored in a deep freeze.

The Manual Digs test procedure was included in Appendix A. The procedure was modified in the field as described above.

3.2.2 Root Washing

When the root samples were collected, the obvious soil was removed. Additional cleaning was required before the samples could be dried.

The root samples were stored in zip lock plastic bags inside a picnic cooler. The picnic cooler was stored in a walk-in-freezer.

The samples from one manual dig were removed from the picnic cooler and the zip lock plastic bags were ordered on the laboratory bench. The root fragments from the first frame, i.e. the top sample, were visually examined. Using a pruning shears, the tops were trimmed to near the plant crown. This removed the plant tops from the sample. The material removed was saved in a separate zip lock plastic bag but it was not used any further. Each root sample was then individually washed, dried with a towel, weighed and repackaged. When all of the samples from one manual dig were washed, weighed and repackaged, the repackaged sample bags were collected into a new zip lock plastic bag and returned to the picnic cooler.

The root fragments were gently hand-washed under warm tap water. The root fragments were blotted dry using kitchen paper hand towels. The root fragments were then weighed using a Mettler PC2000 scale. The scale calibration was checked prior to any sample weighing and after the sample weighing was complete. The zip lock plastic bags were washed and dried inside and the root fragments were repackaged into the same bag. The sample handling ensured the root fragments were thawed for a minimum amount of time.

The root washing test procedure was included in Appendix B.

3.2.3 Root Drying

The frozen washed roots were plunged into liquid nitrogen and placed in a Labconco Freeze Drier (Labconco, Kansas City, MO). The samples were dried for 72 hours. The samples were weighed using a Mettler PC2000 scale. The dried and weighed samples were stored in glass jars at 4°C.

3.2.4 Soil Sample Analysis

The soil samples were analyzed using particle-size analysis by a modified pipette procedure following Indorante, S.J., L.R. Follmer, R.D. Hammer and P.G. Koenig. 1990. SSSAJ 54:560-563. The procedure used to analysis the soil samples was included in Appendix C.

3.3 Experimental Methods - Mechanical Harvester Evaluation

During the travel phase of the project, the AMAC Model G2 harvester, the Bartschi FOBRO Super HD Lifter/Shaker, the Weening Brothers Manufacturing, Ginsenger and the Gallenberg Equipment, Ginseng Digger harvesters were evaluated for the mechanical harvesting of *E. angustifolia*. The AMAC Model G2 harvester had many positive features but it was judged too expensive for Saskatchewan growers. The Weening Brothers Manufacturing, Ginsenger and the Gallenberg Equipment, Ginseng Digger harvesters were nearly identical harvesters. Two harvesters were rented and field tested. A Bartschi FOBRO Super HD Lifter/Shaker was rented from the B.C. Ministry of Forests, Surrey Nursery, Surrey, B.C. and a Weening Brothers Manufacturing, Ginsenger was rented from the manufacturer. Both were tested at Blue Hills Herb Farm Inc. The FOBRO harvester had an oscillating under-cutter-blade and lifting/shaking bars which raised the roots to the surface. The Ginsenger had a stationary under-cutter-blade and a digging chain. The Ginsenger was equipped with hook chain and three-sided-rollers for chain agitation. Belted chain was reported to be gentler on the crop and hydraulic chain agitation would have permitted the chain agitation to be adjusted independent of the chain speed. The FOBRO and the Ginsenger harvesters provided good representation of existing commercial root harvesters.

The FOBRO was tested in three-year-old plants in clay silt and clay loam soil. The Ginsenger was tested in three-year-old plants in clay silt and clay loam soil and in two-year-old plants in sandy loam soil. Table 3.3 summarizes the mechanical harvesting trials.

Plant Age (years)	Planting Method	Soil Type	Harvester
3	transplant	clay silt & clay loam	Ginsenger
3	transplant	clay silt & clay loam	FOBRO
2	transplant	sandy loam	Ginsenger

Table 3.3 Mechanical Harvesting Trials

A Massey Ferguson 2705 tractor pulled the Ginsenger and provided power for the digging chain. A John Deere 3130 tractor carried the FOBRO and provided power to the digging mechanism.

Neither harvester had the capacity to load the roots. The farmers walked behind the harvesters and collected the roots on the soil surface. After the farmers removed the roots on the soil surface, manual digs were conducted to assess the weight of roots dug by the harvester but buried below the soil surface. This root was deemed harvested but uncollectible. Three manual digs were conducted for each mechanical harvesting trial. The manual digs were uniformly distributed in the area harvested for each trial.

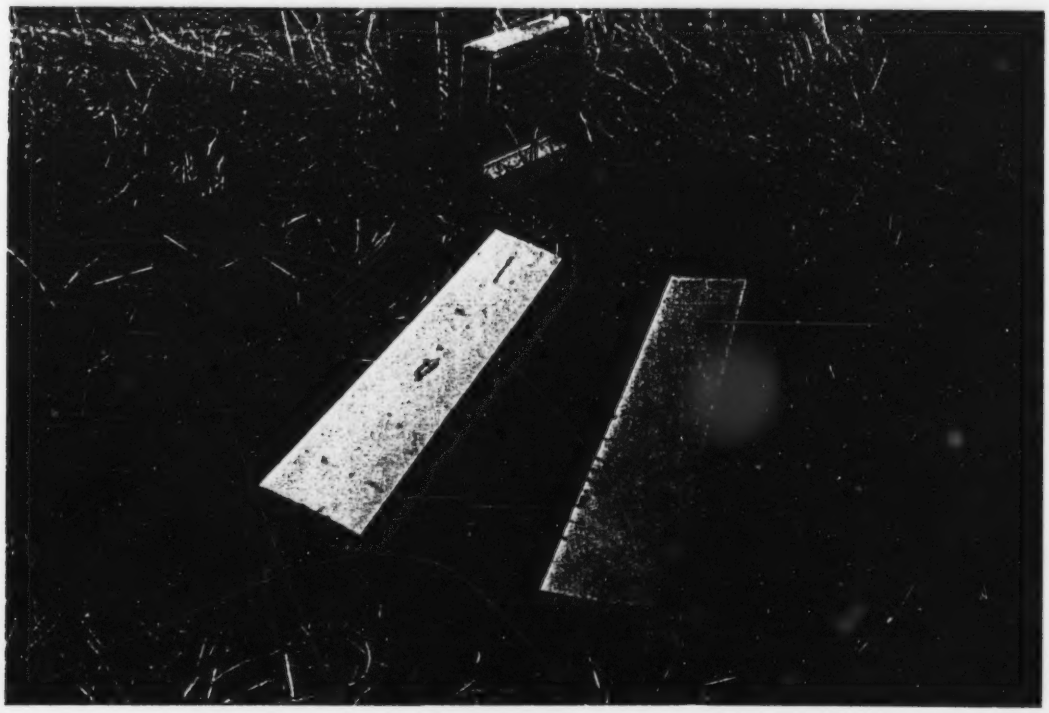


Photo 5 Manual Dig for Mechanical Harvesting Trial

A rectangular area was marked using two wooden boards. The area was the width of the harvester and 300 mm long parallel to the rows. The boards were 1.65 m long. The soil in the rectangular area was excavated with a shovel to the harvesting depth. The difference in soil compaction between the harvested and unharvested soil marked the harvesting depth. The soil removed from the manual dig was sifted for root fragments. The sifting box had a wire mesh screen with an opening 11 mm square. The obvious soil was removed from around the root fragments. The root fragments were packaged into labelled zip lock plastic bags. The harvesting depth was measured using a tape measure. At the end of the day the samples were placed in a deepfreeze.

Engineering observations were made during the mechanical harvesting trials. Following the mechanical harvesting trials the farmers were solicited for their observations.

The Mechanical Harvester Evaluation test procedure was included in Appendix D. The procedure in Appendix D was modified to accommodate the field situation.

The root fragments collected during the mechanical harvesting trials were washed following the methods discussed in section 3.2.2 and dried following the methods discussed in section 3.2.3.

Chapter 4

Observations

4.1 Observations - Visits to Root Harvester Suppliers

The combination of a grower and an engineer provided a comprehensive investigation that could not have been completed by either alone. The visits highlighted production opportunities from mechanization and integrated production methods. The visits presented harvesters with a range of features and indicated that adaptation to Saskatchewan soils and *E. angustifolia* may be necessary.

The farms visited varied in the level of production sophistication. The most sophisticated farm was a farm in Washington that produced 1200 acres of carrots and 400 acres of onions. This farm had very integrated and high-capacity production methods. The fields were level. The crops were grown in carefully shaped and perfectly straight raised beds. The area was a desert and irrigation provided most of the crops water requirements. The plant tops were precisely removed prior to harvesting using a rotary flail followed by a specialized crowner. The crop was harvested using a high-capacity fully-automatic harvester that loaded the crop into semi-trailers for transport to a processor. The other farms visited were not as sophisticated but all used mechanization and an integrated systems approach to planting, weeding and harvesting.

Three root harvesters, each manufactured by a different company, were observed operating in the field: AMAC Model G2, Bartschi FOBRO Super HD Lifter/Shaker and Weening Brothers Manufacturing Ginsenger. All three harvesters were operated in sandy soils. Use of any of these harvesters in Saskatchewan soils may require a prior operation to loosen the soil. Many other non-operating harvesters were also observed. The AMAC Model G2 was observed in Washington harvesting carrots. The harvester was a high-capacity automatic full-feature harvester. The primary digging tool was a row of carrot pins that can be rotated to adjust the digging depth. The advantage of the carrot pins was that if they caught the subsoil and bent they could be easily replaced. The harvester features permitted effective soil, stone and trash removal prior to automatic loading into a truck. A used older model AMAC harvester cost $34,000 and was considered too expensive for Saskatchewan Echinacea growers. The Bartschi FOBRO Super HD Lifter/Shaker was operated in a fallow field at a Washington tree nursery. The Bartschi FOBRO Super HD Lifter/Shaker was the smallest harvester and the only harvester which attached to the tractor using a three-point hitch. The primary digging tool was an oscillating under-cutter-blade. The harvester lifted the roots to the soil surface where the roots were manually collected. This harvester was the only one that during the tours was reported by a farmer to be operated in clay soils. The design and construction of the harvester indicated that it may achieve the deepest digging depth of the three harvesters observed operating. A new Bartschi FOBRO Super HD Lifter/Shaker costs $17,000 and was one of the least expensive new harvesters. Unfortunately, the supplier did not sell used-harvesters. The Weening Brothers Manufacturing Ginsenger was observed harvesting *E. purpurea* in southern Ontario. The Weening Brothers Manufacturing, Ginsenger and the Gallenberg Equipment, Ginseng Digger harvesters were very similar harvesters. Both had an under-cutter-blade as the primary digging tool and both used a digging chain with mechanical or hydraulic agitation. These harvesters dropped the roots onto the soil surface. Manual collection was required. Harvesters were available with additional features for soil, stone and trash removal and automatic truck loading from both manufacturers. The depressed ginseng market made used harvesters readily available. Used harvesters cost about $10,000. The design and construction of the Weening Brothers Manufacturing, Ginsenger and the

Gallenberg Equipment, Ginseng Digger indicated that these harvesters may require modification to dig sufficiently deep for Saskatchewan Echinacea growers. Table 4.1 summarized the features of the four harvesters evaluated during the travel.

Appendix E included the detailed observations that were made during the travel. Appendix F included copies of equipment brochures collected during the travel.

Manufacturer	Amac B.V. Holland	Bartschi-FOBRO Switzerland	Weening Brothers Manufacturing Inc. Kettleby, Ontario	Gallenberg Equipment, Inc. Antigo, Wisconsin
Supplier	Mr. Bob Merrell KPR Incorporated P.O. Box 608, 375 West Avenue "D" WENDELL, IDAHO 83355-0608 Tel. (208) 536-6601	Bartschi-FOBRO 1715 Airpark Drive, P.O. Box 651 GRAND HAVEN, MICHIGAN 49417 Tel. (616) 847-0300	Mr. Fred Weening Weening Brothers Manufacturing Inc. Wist Road, R.R. #1 KETTLEBY ONTARIO L0G 1J0 Tel. (905) 775-3839	Mr. Rueben Hintz Gallenberg Equipment, Inc. W9112 Cherry Rd. ANTIGO WI 54409 Tel. (715) 623-3754
Model	G2	Super HD Lifter/Shaker	Ginsenger	Ginseng Digger
Harvesting Width (in)	59, 67	53, 59, 67	64	67
Harvesting Depth (in)	14	12	12	9
Capacity (acres/day)	20	< 1	2	2
Tractor Attachment	drawbar	three-point hitch	drawbar	drawbar
Minimum Tractor HP	90	65	65	?
Weight (lb)	10,400	2,000	?	3,700
Length	27'3"	6'	18'6"	16'3"
Width	9'4"	6' estimated	8'6"	7'9"
Primary Digging Tool	rotatable carrot pins	oscillating undercutter blade	undercutter blade	undercutter blade

General Operation	Complete harvesting and elevation into a truck.	Lifting/shaking bars raise roots to the surface. Manual root collection. A combine is available to lift roots off surface and load into a truck.	Windrow. Manual root collection. Complete harvesting and elevation into a truck requires custom modification.	Windrow. Manual root collection. A harvester for complete harvesting and elevation into a truck is available.
Primary Crop	wide range of vegetable crops	nursery bareroot stock	ginseng	ginseng
Cost ($ CDN)	93,000 new 34,000 used	17,000 new used not available from the supplier	16,000 new 11,000 used	23,000 new 10,000 used

Table 4.1 Existing Commercial Root Harvester Summary

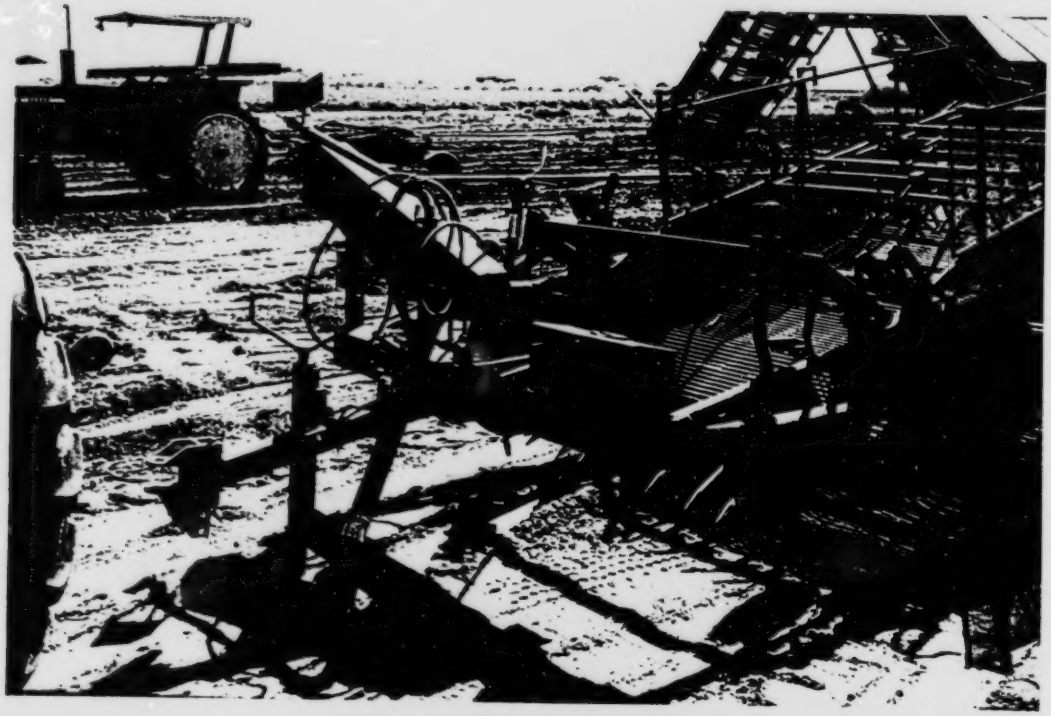


Photo 6 AMAC Harvester

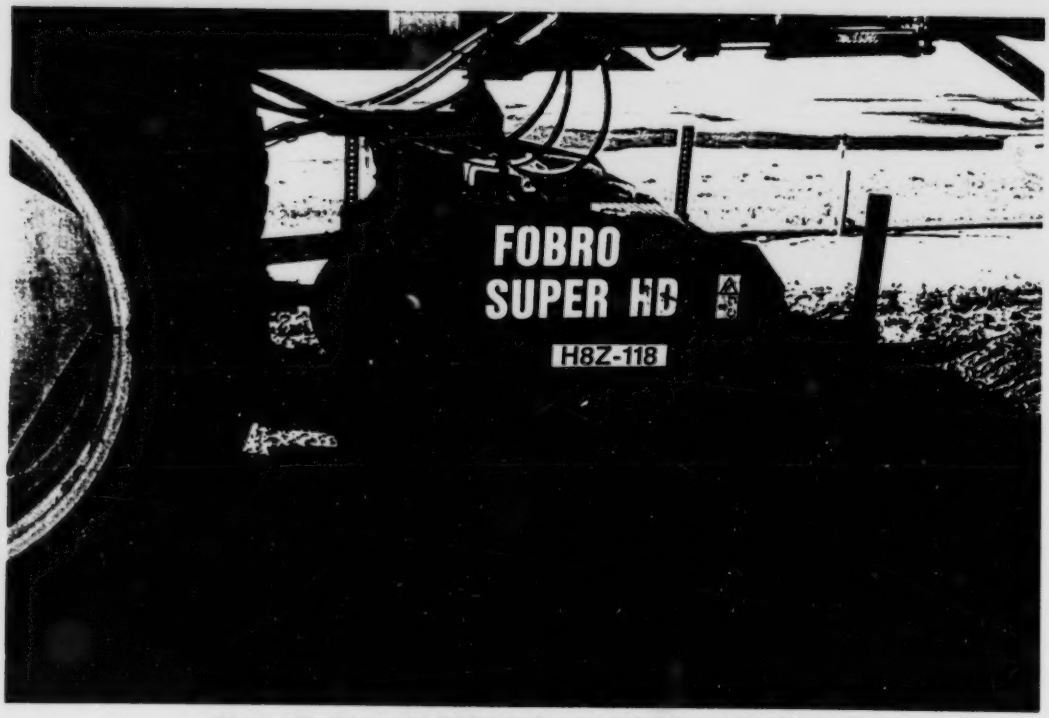


Photo 7 Bartschi FOBRO Super HD Lifter/Shaker

Photo 8 Weening Brothers Manufacturing Ginsenger

Photo 9 Gallenberg Equipment, Ginseng Digger

4.2 Observations - Root Distribution

The manual digs at Blue Hills Herb Farm Inc. were conducted on October 19, 20 and 21. The fields were dry. The plant tops were intact and mechanical harvesting had not started. The manual digs at the farm of Wendy James and Ron Gillies were conducted on November 4. The field was very wet. Mr. Gillies estimated that he had applied about 140 mm (5 1/2") of water to the field from a dugout adjacent to the field. The field was watered to make mechanical harvesting easier. The plant tops were completely removed and only one row was available for manual digs.

At Blue Hills Herb Farms Inc. the row spacing varied from 1000 mm (40") to 1800 mm (72"). The spacing in-the-row of the transplanted plants varied from 75 mm (3") to 150 mm (6"). The spacing in-the-row of the direct-seeded plants was variable but at the locations where manual digs were performed it was 16 plants per 300 mm (16 plants per foot). The farm of Wendy James and Ron Gillies had a double row planting. The rows in the double row were 150 mm (6") apart. The plants in a row were 150 mm (6") apart. The plants in the two rows were directly opposite each other and not staggered. The path between the double rows was 660 mm (26").

Blue Hills Herb Farm Inc. reported few problems with disease while the farm of Wendy James and Ron Gillies reported significant problems with disease.

Ten manual digs were completed; eight of the manual digs were at Blue Hills Herb Farm Inc. and two of the digs were at the farm of Wendy James and Ron Gillies. Six of the digs involved three-year-old plants and four of the digs involved two-year-old plants. One dig was in silt clay, another was in clay loam, six of the digs were in sandy loam soil and two of digs were in loam soil. The root fragment samples were collected from frames 850 mm by 300 mm by 90 mm thick. Six frames were collected for each dig performed in three-year-old plants. Four frames were collected for each dig performed in two-year-old plants. The roots of the three-year-old plants were extracted to a depth of 540 mm. Below 540 mm, the roots of three-year-old plants extended however the roots appeared to be mostly the main tap roots with few laterals. The root system appeared much less dense below 540 mm compared to regions in the soil above 540 mm. Also, existing mechanical root harvesting equipment has a maximum digging depth of 355 mm (14"). The roots of the two-year-old plants were extracted to a depth of 360 mm. The roots of the two-year-old plants studied were very small below 360 mm and were judged too small for mechanical harvesting. Fifty-two root samples were collected during the manual digs. Table 4.2 through 4.11 include the wet weight, the dried weight and the dried weight percentage for each sample. Table 4.12 lists the soil sample analysis results.

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	100.80	37.28	36.6
2	67.74	25.94	25.5
3	36.01	13.77	13.5
4	17.91	6.95	6.8
5	26.83	10.30	10.1
6	20.48	7.54	7.4
Total	269.77	101.78	

Table 4.2 Blue Hills Herb Farm, Clay, 3 Year Transplant, Rep 1

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	44.52	17.01	20.2
2	55.52	20.98	24.9
3	41.90	16.25	19.3
4	34.39	13.80	16.4
5	23.69	9.25	11.0
6	19.07	6.86	8.2
Total	219.09	84.15	

Table 4.3 Blue Hills Herb Farm, Clay, 3 Year Transplant, Rep 2

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	45.09	18.47	12.8
2	81.91	34.09	23.6
3	79.72	32.84	22.7
4	77.99	32.60	22.5
5	40.92	17.08	11.8
6	26.08	9.65	6.7
Total	351.71	144.73	

Table 4.4 Blue Hills Herb Farm, Sand, 3 Year Transplant, Rep 1

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	64.23	23.16	20.6
2	93.24	35.54	31.7
3	40.20	15.14	13.5
4	36.29	13.74	12.2
5	37.76	14.04	12.5
6	25.92	10.57	9.4
Total	297.64	112.19	

Table 4.5 Blue Hills Herb Farm, Sand, 3 Year Transplant, Rep 2

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	37.75	13.49	51.0
2	15.47	5.67	21.4
3	13.10	4.89	18.5
4	6.59	2.42	9.1
Total	72.91	26.47	

Table 4.6 Blue Hills Herb Farm, Sand, 2 Year Transplant, Rep 1

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	33.10	11.54	29.5
2	38.68	13.64	34.9
3	28.28	9.68	24.8
4	12.37	4.23	10.8
Total	112.43	39.09	

Table 4.7 Blue Hills Herb Farm, Sand, 2 Year Transplant, Rep 2

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	67.12	23.85	38.9
2	53.05	19.65	32.0
3	25.88	9.52	15.5
4	21.13	8.30	13.5
Total	167.18	61.32	

Table 4.8 Blue Hills Herb Farm, Sand, 2 Year Direct-Seed, Rep 1

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	45.01	16.05	22.2
2	119.89	41.12	56.9
3	26.10	9.51	13.2
4	15.28	5.58	7.7
Total	206.28	72.26	

Table 4.9 Blue Hills Herb Farm, Sand, 2 Year Direct-Seed, Rep 2

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	39.00	13.15	18.6
2	39.49	14.62	20.7
3	33.08	12.35	17.5
4	28.20	10.25	14.5
5	39.62	14.54	20.6
6	16.06	5.72	8.1
Total	195.45	70.63	

Table 4.10 Wendy James/Ron Gillies, Sand, 3 Year Transplant, Rep 1

Frame	Wet Weight (grams)	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)
1	55.57	18.71	18.3
2	63.38	21.53	21.1
3	61.36	21.25	20.8
4	45.28	16.08	15.7
5	49.08	18.00	17.6
6	18.16	6.64	6.5
Total	292.83	102.21	

Table 4.11 Wendy James/Ron Gillies, Sand, 3 Year Transplant, Rep 2

Site	Soil Class	Plant Age (years)	Planting Method	Rep.	Particle Breakdown		
					Sand (%)	Clay (%)	Silt (%)
Blue Hills Herb Farm Inc.	silt clay	3	trans.	1	17.3	41.3	41.4
Blue Hills Herb Farm Inc.	clay loam	3	trans.	2	25.5	31.2	43.3
Blue Hills Herb Farm Inc.	sandy loam	3	trans.	1	75.9	8.6	15.5
Blue Hills Herb Farm Inc.	sandy loam	3	trans.	2	71.7	6.7	21.6
Blue Hills Herb Farm Inc.	sandy loam	2	trans.	1	67.6	7.6	24.8
Blue Hills Herb Farm Inc.	sandy loam	2	trans.	2	61.9	12.1	26.0
Blue Hills Herb Farm Inc.	sandy loam	2	direct-seeded	1	76.8	14.0	9.2
Blue Hills Herb Farm Inc.	sandy loam	2	direct-seeded	2	74.2	9.7	16.1
Farm of Wendy James and Ron Gillies	loam	3	trans.	1	45.7	12.7	41.6
Farm of Wendy James and Ron Gillies	loam	3	trans.	2	39.7	23.2	37.1

Table 4.12 Soil Samples Analysis Results

The total dry weight of roots collected from the manual digs in three-year-old plants were compared in Table 4.13. The average total dry weight was 102.6 grams. The standard deviation was 25.4 grams. The data collected at Blue Hills Herb Farm Inc. suggested a production advantage in sandy loam soil.

Site	Soil Class	Replicate	Dry Weight (grams)
Blue Hills Herb Farm Inc.	silt clay	1	101.78
Blue Hills Herb Farm Inc.	clay loam	2	84.15
Blue Hills Herb Farm Inc.	sandy loam	1	144.73
Blue Hills Herb Farm Inc.	sandy loam	2	112.19
Farm of Wendy James and Ron Gillies	loam	1	70.63
Farm of Wendy James and Ron Gillies	loam	2	102.21

Table 4.13 Total Dry Weight of Three-Year-old Plants

The total dry weight of roots collected from the manual digs in two-year-old plants were compared in Table 4.14. All of these samples were collected at Blue Hills Herb Farm Inc. and all were from sandy loam soil. The average total weight of the roots from transplanted plants was 32.8 grams per 300 mm of row. The average total dry weight of the roots from direct-seeded plants was 66.8 grams per 300 mm of row. The direct-seeded plants yielded higher weights than the transplanted plants. The difference was due partly to the difference in planting density: three plants per 300 mm of row in the transplanted plants and sixteen or seventeen plants per 300 mm of row in the direct-seeded plants.

Planting Method	Soil Type	Replicate	Dry Weight (grams)
transplant	sandy loam	1	26.47
transplant	sandy loam	2	39.09
direct-seeded	sandy loam	1	61.32
direct-seeded	sandy loam	2	72.26

Table 4.14 Total Dry Weight of Two-Year-old Plants

The total dry weight of roots in the top 360 mm, i.e., the top four frames, was computed for the six manual digs in three-year-old plants. The mean total dry weight was 80.8 grams and the standard deviation was 22.6 grams. The average total dry weight of roots from two-year-old direct-seeded plants was 66.8 grams. The direct-seeded two-year-old plants have a productivity similar to the three-year-old transplanted plants based on the cropping practices at Blue Hills Herb Farms, Inc., i.e., small plant spacing for the direct-seeded plants compared with the transplanted plants.

It was possible to compare the root dry weight vertical distribution by adding together the dry weights above different digging depths and computing a percentage. The variation in the actual root weight between the various digs was eliminated by dividing the dry weight above a particular digging depth by the total dry weight for the entire dig. Table 4.15 shows the vertical distribution of the root dry weight for three-year-old plants and Table 4.16 shows the vertical distribution of the root dry weight for two-year-old plants.

Dig'g Depth (mm)	Blue Hills Herb Farm Inc.				Farm of Wendy James and Ron Gillies		Mean Dry Weight (%)	Std. Dev. (%)
	Silt Clay	Clay Loam	Sandy Loam		Loam			
	Rep 1 (%)	Rep 2 (%)	Rep 1 (%)	Rep 2 (%)	Rep 1 (%)	Rep 2 (%)		
90	36.6	20.2	12.8	20.6	18.6	18.3	21.2	8.1
180	62.1	45.1	36.4	52.3	39.3	39.4	45.8	9.8
270	75.6	64.4	59.1	65.8	56.8	60.2	63.6	6.7
360	82.4	80.8	81.6	78.0	71.3	75.9	78.3	4.2
450	92.5	91.8	93.4	90.5	91.9	93.5	92.3	1.1
540	99.9	100.0	100.0	99.9	100.0	100.0		

Table 4.15 Vertical Weight Distribution in Three-Year-old Plants

Dig'g Depth (mm)	Blue Hills Herb Farm Inc.				Mean Dry Weight (%)	Std. Dev. (%)
	Transplant		Direct-seeded			
	Rep 1 (%)	Rep 2 (%)	Rep 1 (%)	Rep 2 (%)		
90	51.0	29.5	38.9	22.2	35.4	12.4
180	72.4	64.4	70.9	79.1	71.7	6.0
270	90.9	89.2	86.4	92.3	89.7	2.5
360	100.0	100.0	99.9	100.0		

Table 4.16 Vertical Weight Distribution in Two-Year-old Plants

The results in Table 4.15 indicated that the vertical dry-weight root distribution was not affected by soil type or site. These results further suggested that: 64% of the dry weight of roots could be collected with a digging depth of 270 mm, 78% of the dry weight of roots could be collected with a digging depth of 360 mm and 92% of the dry weight of roots could be collected with a digging depth of 450 mm. The collectible roots percentages only included roots in the top 540 mm. The root system was observed to be much less dense below 540 mm and mechanical harvesting depths below 540 mm were judged to be challenging.

The roots of the two-year-old plants were very small below 360 mm and were judged too small for mechanical harvesting. The results in Table 4.16 suggested that: 72% of the dry weight of roots could be collected with a digging depth of 180 mm and 90% of the dry weight of roots could be collected with a digging depth of 270 mm.

The horizontal root distribution was visually assessed and recorded as the manual digs were conducted. It was observed that on occasion roots were distributed horizontally across the manual dig but most often the roots were concentrated in a region 150 mm either side of the row. The region between 270 mm and 360 mm showed the largest horizontal distribution of larger diameter roots.

The observations made during the manual digs and the detailed results from the manual digs were included in Appendix G.

4.3 Observations - Mechanical Harvester Evaluation

On October 23 and 24, Blue Hills Herb Farm Inc. conducted most of their harvesting. Prior to harvest the plant tops were removed about 100 mm above the soil surface using a swather. The harvesting was performed using an FMC FoodTech Beet and Carrot harvester. The Ginsenger made a second pass to recover root fragments left by the FMC harvester.

The FMC harvester was designed to dig, top and load red beets, carrots, turnips, parsnips and rutabagas. The FMC FoodTech harvester was no longer being manufactured. ASA-Lift A/S, Denmark manufactured a similar harvester, but the manufacturer indicated that this harvester was not suitable for Echinacea. Engineers did not observe the FMC harvester operate.

On October 28, mechanical harvesting trials were conducted at Blue Hills Herb Farm Inc. using the Weening Brothers Manufacturing, Ginsenger and the Bartschi FOBRO Super HD Lifter/Shaker. The soil conditions were dry.

The first harvesting trial was on three-year-old transplants in silt clay and clay loam soil using the Ginsenger. The Massey Ferguson 2705 tractor was operated at an engine speed of 2000 rpm and in the lowest gear. Based on the tractor engine speed, the PTO speed was 540 rpm. The plants had been previously harvested using the FMC harvester. The field was approximately 200 m long. The Ginsenger made three passes in the field. Each strip harvested with the Ginsenger was not previously harvested with the Ginsenger. The Ginsenger harvested two rows at a time. At three uniformly distributed sites in the harvested area manual digs were conducted to assess the digging depth of the Ginsenger and the amount of roots dug by the Ginsenger which remained below the soil surface and which was uncollectible. It was observed that the FMC harvester dug to a depth of 225 mm. The Ginsenger was set to dig 225 mm deep but the measured average digging depth was 190 mm. The tractor operator commented that the tractor was not working very hard. The average dry weight of the uncollectible root fragments from the three manual digs were 13.8 grams. The soil broke into large clods. Some of the uncollectible root fragments were trapped inside the clods. The large clods also restricted the soil from dropping through the digging chain and restricted the separation of the root fragments from the soil.

Photo 10 Ginsenger Harvesting in Silt Clay and Clay Loam Soil

The second harvesting trial was conducted in the same field, i.e., three-year-old transplants in silt clay and clay loam soil, as the first harvesting trial, using the FOBRO harvester. A strip, approximately 20 m long, of one row had not been harvested with the FMC harvester and this strip was used for the second harvesting trial. The FOBRO was carried and powered by a John Deere 3130 tractor. After the FOBRO harvested the strip, the farmers collected the roots on the soil surface. Using pruning shears, the tops were trimmed. At three uniformly distributed sites manual digs were conducted to assess the digging depth of the FOBRO and the amount of the root dug by the FOBRO which remained below the soil surface and which was uncollectible. The average digging depth was 215 mm. The average dry weight of the uncollectible root fragments from the three manual digs were 16.1 grams.

The rear ends of the tines that followed the oscillating under-cutter-blade of the FOBRO harvester were below the soil surface during the harvesting trial. Adjustment of the top link of the three-point-hitch would have lifted the rear ends of the tines above the soil surface. It was anticipated that this adjustment may have assisted the harvester to move the roots to the soil surface more effectively. Earlier operation of the FOBRO in clay loam soil demonstrated that this adjustment caused the FOBRO to work so aggressively in the hard soil that it jerked the tractor back and forth. Prior to harvest, loosening the soil may have reduced this problem.

Similar to the Ginsenger, the soil broke into large clods. Some root fragments were trapped in the clods while other root fragments were prevented from moving to the soil

surface by the clods.

Photo 11 FOBRO Harvesting in Silt Clay and Clay Loam Soil

The third harvesting trial was on two-year-old transplants in sandy loam soil using the Ginsenger. The Massey Ferguson 2705 tractor operation was the same as the first harvesting trial, i.e., an engine speed of 2000 rpm, the lowest gear and 540-rpm PTO speed. A strip of one row approximately 15 m's long was harvested. Prior to harvest the tops were removed with a swather to within 75 mm to 100 mm of the soil surface. The tractor operator attempted to dig 300 mm deep but approximately every 3 m the tractor lost traction and the front of the Ginsenger was lifted to reduce the drag from the Ginsenger. The tractor operator commented that the tractor was working hard. After harvesting, the roots were manually collected from the soil surface. The roots were easy to locate and the root systems were nearly intact. Soil clods were not a problem as they were in the previous harvesting trials. At three uniformly distributed sites manual digs were conducted to assess the digging depth of the Ginsenger and the amount of roots dug by the Ginsenger which remained below the soil surface and which was uncollectible. The average digging depth was 320 mm. The average dry weight of the uncollectible root fragments was 1.8 grams. The manual digs revealed that the soil profile was not significantly disturbed by the harvesting.

Appendix H includes the detailed observations made during the mechanical harvesting trials.

The mechanical harvesting trials were conducted in the same fields where manual digs

had been conducted earlier to determine the vertical distribution of the weight of the roots. Both sets of manual digs were conducted in areas 300 mm parallel to the row. The manual digs for the mechanical harvesting trials were much longer perpendicular to the row than the manual digs to determine the vertical distribution of the weight of the roots. The manual digs to determine the vertical distribution of the weight of the roots indicated that most of the roots were concentrated in a region 150 mm on either side of the row. It was therefore possible to compare the weights measured in the two manual digs based on the number of rows harvested. The average digging depth and the number of rows harvested from the mechanical harvesting trials were used to compute the average dry weight of roots available for harvest based on the manual digs to determine the vertical distribution of the weight of the roots. Within each soil slice, the root weight was assumed to be uniformly distributed vertically. Table 4.17 lists the mean and standard deviation of the dry weight of uncollectible root fragments, the harvester average digging depth, the number of rows harvested, the dry weight of roots available for harvesting and the percentage of the uncollected root.

Soil Type	Plant Age (years)	Harvtr.	Uncoll. Mean Dry Weight (grams)	Std. Dev. (grams)	Ave. Digging Depth (mm)	# of Rows	Avail. Dry Weight (grams)	Uncoll. (%)
clay	3	Gins.	13.8	7.0	190	2	104.6	13
clay	3	FOBRO	16.1	5.6	215	1	56.4	29
sandy	2	Gins.	1.8	1.9	320	1	31.3	6

Table 4.17 Harvester Performance

Thirteen percent of the roots from three-year-old plants in silt clay and clay loam soil which were harvested by the Ginsenger were uncollectible while 29% of the roots from three-year-old plants in silt clay and clay loam soil harvested by the FOBRO were uncollectible. Six percent of the roots from two-year-old plants in sandy loam soil which were harvested by the Ginsenger were uncollectible.

Chapter 5

Conclusions

Visits were made to five equipment suppliers to evaluate a wide range of existing commercial root harvesting equipment. The farms toured during the visits varied in the level of production sophistication. All the farms used mechanization and all had an integrated approach to planting, weeding and harvesting. The crops were planted to accommodate weeding equipment and harvesting equipment. Further, the planting, weeding and harvesting equipment were designed or adapted to the crop under production. Saskatchewan *E. angustifolia* growers will achieve more effective production by using equipment adapted to *E. angustifolia* and by integrating planting, weeding and harvesting.

The vertical dry-weight root distribution of three-year-old plants was not affected by the site or the soil type. Manual digs indicated that: 64% of the dry weight of roots could be collected with a digging depth of 270 mm, 78% of the dry weight of roots could be collected with a digging depth of 360 mm and 92% of the dry weight of roots could be collected with a digging depth of 450 mm. The roots extended below 540 mm however they were mostly smaller main tap roots with few laterals. Most existing commercial root harvesters can dig 360 mm deep with little or no modification. These harvesters will harvest nearly 80% of the total dry weight of roots in the top 540 mm.

The vertical dry-weight root distribution of two-year-old plants was not affected by the planting method, i.e., transplanted or direct-seeded. Manual digs indicated that below 360 mm, the roots were judged too small for mechanical harvesting. The manual digs also indicated that: 72% of the dry weight of roots could be collected with a digging depth of 180 mm and 90% of the dry weight of roots could be collected with a digging depth of 270 mm. Existing commercial root harvesters will harvest 100% of the total dry weight of roots available.

The manual digs indicated a mean total dry root weight of 80.8 grams per 300 mm of row in the top 360 mm for three-year-old transplanted plants and a mean total dry root weight of 66.8 grams per 300 mm of row in the top 360 mm of two-year-old direct-seeded plants. The dry root weight of the two-year-old direct-seeded plants was considered comparable to the dry root weight of the three-year-old transplanted plants based on the same length along the row. The roots of the three-year-old transplanted plants were larger than the roots of the two-year-old direct-seeded plants but the two-year-old direct-seeded plants were more densely seeded along the row.

The manual digs extended 425 mm on either side of the row. On occasion the roots were distributed horizontally across the manual dig but most often the roots were concentrated in a region 150 mm either side of the row.

Harvesting in silt clay and clay loam soil was difficult for the FOBRO and the Ginsenger. The soil broke into large clods. Some root fragments were trapped in the clods. The clods restricted the soil from dropping through the digging chain of the Ginsenger and restricted the separation of the root fragments from the soil. The clods restricted the FOBRO's ability to sift the root fragments from the soil. Adjustment of the FOBRO for optimum harvesting caused the FOBRO to work so aggressively that it jerked the tractor back and forth. Manual digs performed after mechanical harvesting with the FOBRO indicated 29% of the root harvested was uncollectible and with the Ginsenger indicated 13% of the root harvested was uncollectible. The mechanical harvesting trials indicated that Saskatchewan

E. Angustifolia growers should avoid silt clay and clay loam soils.

The Ginsenger was tested in sandy loam soil on the two-year-old transplanted plants. Soil clods were not a problem. The Ginsenger placed the roots on the soil surface and left the plant root system nearly intact. Manual digs performed after mechanical harvesting with the Ginsenger indicated 6% of the root harvested was uncollectible. The soil profile was not significantly disturbed by the harvesting operation. The Ginsenger satisfactorily harvested the roots of two-year-old plants from sandy loam soil.

Chapter 6

Future Development

The manual digs assessed the vertical dry-weight root distribution. The average root diameter declined with digging depth. Recent research has indicated that the concentration of marker compounds is highest in the smallest diameter roots. Some buyers pay a premium to growers for roots with a higher concentration of marker compounds. It is recommended that the dried roots collected during the manual digs be analysed for the concentration of marker compounds and that the recommended digging depths be revised based on this analysis.

The manual digs were conducted primarily at a single site. Only two replicates were collected for each treatment. The results of the manual digs should be compared with the results collected by other researchers, e.g., Crop Diversification Centre - South, Brooks, Alberta. If significant differences exist, it is suggested that additional manual digs be conducted at a range of sites and with a larger number of replicates for each treatment.

The Ginsenger satisfactorily harvested two-year-old plants in sandy loam soil. Prior to harvest the plant tops were removed to within 75 mm to 100 mm of the soil surface. Following harvest, the roots were collected manually off the soil surface and the plant tops were trimmed with pruning shears. A satisfactory method must be found for removing the plant tops. It is recommended that various mechanical topping methods be reviewed and some tested. Further, the harvesting trials should be repeated with the Ginsenger to ensure integration of the topping and harvesting. A suitable tractor should be selected for the Ginsenger. Retrofitting the Ginsenger with hydraulic agitation and belted chain should be considered. Collecting the roots on the soil surface following harvest was labour intensive. Mechanization of the root collection may be considered.

The harvesting width of the Ginsenger was 1600 mm. A harvesting width between 300 mm and 800 mm would be suited to the cultural practices at Blue Hills Herb Farm Inc. Other Saskatchewan growers reported different cultural practices. If single rows and wide row spacings become the dominant cultural practice then the Ginsenger harvesting width should be reduced to between 300 mm and 800 mm.

Mechanical harvesting in silt clay and clay loam soil was difficult. If production of *E. angustifolia* in clay soils is important for Saskatchewan growers then significant modifications must be developed for existing commercial root harvesters.

Pre working the soil to loosen the soil prior to harvest was encouraged during the travel phase of the project. Tests should be conducted to measure the effects when the soil is pre worked prior to harvest.

The nursery trades were reported to use root wrenching to encourage root development near the soil surface. Root wrenching involved passing a thin blade under the root zone during the growing season. The blade disturbs the soil which encourages root development nearer the soil surface. It is recommended that trials be conducted to assess the effect of root wrenching on *E. angustifolia*.

Observations made during the manual digs indicated that the top 90 mm had few lateral roots. It was speculated that roto tilling discouraged root growth in this region. Some organic weed control methods do not penetrate the soil surface. It is recommended that these

weed control methods and their effect on root development be investigated.

Chapter 7

Communication of Results

Mr. Victor Taylor prepared an article for the December newsletter of the Saskatchewan Herb and Spice Association. The article was entitled 'Looking for Root Digging Equipment?'. A copy of the article was included in Appendix I.

Mr. Myles Bantle made a presentation at the Saskatchewan Herb and Spice Association, Herb and Spice Day, January 14, 2000. The presentation was entitled 'Mechanical Harvesting of Echinacea Roots'. A copy of the article submitted to the conference proceedings was included in Appendix J.

A paper abstract was submitted to the International Herb Conference scheduled for July 18 - 21, 2000 in Saskatoon.

Appendix A

Manual Digs Test Procedure

October 18, 1999

Test Procedure 9942-01

Test Objective

The objective of this test procedure is to quantify the distribution of roots vertically at Blue Hills Herb Farm in fields of two year old and three year old plants in both sandy loam and clay loam using manual diggings. The vertical root distribution will be quantified in six vertical segments each 90 mm thick starting at the soil surface.

Test Equipment

- tape measure
- 8 soil pegs
- roll of string
- pruning shears
- woods frames made from 1 by 4s with inside dimensions of 850 mm by 300 mm
- 2 spades
- floor scraper
- hand garden shovel
- knife with a 250 mm long serrated blade
- hand saw
- flat blade shovel
- sifting box
- small paint brush
- 100 large ziplock bags
- black marker
- packing tape and tape gun
- 15 small ziplock bags
- 3 cardboard boxes
- 2 coolers
- 3 orange Glad bags
- camera and film

Test Set Up

Test Procedure

1) With the assistance of the farmer select four fields that meet the requirements listed in Table 1.

Field
sandy loam, two year old plants
sandy loam, three year old plants
clay loam, two year old plants
clay loam, three year old plants

Table 1 Test Fields

2) Randomly select three sites (3 replicates) in each field for manually diggings.

3) Using the tape measure, soil pegs and string mark a rectangular area 850 mm by 300 mm. The short dimension of the rectangular area is along the row. The long dimension of the rectangular area is perpendicular to the row. The rectangular area is centred on the row and includes three plants (expected plant spacing 75 mm to 100 mm).

4) Record in the Data Sheets the date, time, field, replicate, actual plant spacing and row spacing.

5) Remove plant tops using a pruning shears to the level required for sale of the roots. Ask farmer for directions and record specific topping details here.

6) Using spades, dig trenches on all sides of the marked area to leave a rectangular volume of soil 850 mm wide, 300 mm long and 540 mm deep.

7) Slide one-at-a-time the six frames with inside dimensions of 850 mm by 300 mm over the rectangular volume of soil. Each frame is 90 mm thick. The stack of frames will be 540 mm high.

8) Run a knife blade or hand saw blade between the top most frame and the next lowest frame to sever the roots between the two frames.

9) Remove the top frame and set aside. Using the flat blade shovel remove the exposed 90 mm of soil and place in the sifting box.

10) Label a large ziplock bag with the date, field description, replicate and frame number (1st, 2nd, 3rd, 4th, 5th or 6th) on both sides using the marker. Gently shake the sifting box and remove the soil from the roots. Using the paint brush, remove as much

soil as possible from the roots. Place the cleaned roots in the labelled ziplock bag. Force as much air as possible from the bag. Close the bag and seal with packing tape. Place filled bag in a cardboard box for transport to the university.

11) Label a small ziplock bag with the date, field description and replicate on both sides using the marker. Fill the bag with soil sifted from the 1st frame. Force as much air as possible from the bag. Close the bag and seal with packing tape. Place filled bag in a cardboard box separate from the cardboard box with the root samples.

12) Repeat step 10 for the 2nd, 3rd, 4th, 5th and 6th frames.

13) Record any observations of roots below the 6th frame.

14) Close the excavation attempting to return the soil in the order it was removed from the excavation. Load root samples into a cooler.

15) Repeat the above steps for the remaining sites in this field and in the three other fields.

16) Take photos a various stages of the excavation.

FORBORO Notes

Maximum RPM 1600
grease each day

Test Data

Date: _____

Time: _____

Field: _____

Replicate: _____

Plant Spacing: _____

Row Spacing: _____

Other Observations and Notes

Appendix B

Root Washing Test Procedure

November 22, 1999

Test Procedure 9942-03

Test Objective

The objective of this test procedure is to wash, weigh and repackage the echinacea root samples collected using Test Procedure 9942-01.

Test Equipment

- 2 aluminum plates
- pruning shears
- large ziplock bags
- Scot Towels
- black marker
- camera, flash and film

Test Set Up

Test Procedure

1) Find a weigh scale. Record the make, model and university identification here.

   Scale Make:
   Scale Model:
   Scale University ID:

2) Remove cooler of root samples from freezer.

3) Select the samples from one manual digging.

4) Record on an individual Data Sheet the date, time and the sample description.

5) Trim the crown to match the Meadow Lake sample. Record in the date sheets the amount of material removed. Label a ziplock bag and place the removed material in the labelled bag. Take photos as appropriate.

5) Remove the roots from the First Frame and place in an aluminum plate.

7) Using tap water and Scot Towels, clean and dry the inside of the sample bag.

8) Under a running tap, gently hand wash the roots and place on a Scot Towel. Gently dry the roots with a Scot Towel. Place surface dry roots in a clean aluminum plate.

9) Weigh the roots in the clean aluminum plate. Record the weigh in the data sheets.

10) Repackage the roots into the cleaned ziplock bag.

11) Repeat steps 5 through 10 for the remaining frames in the digging.

12) Place in the individual bags from the manual digging into a single large ziplock bag. Place this bag back into the cooler.

13) Repeat steps 3 through 12 for the remaining manual diggings.

14) Close cooler and place back into the freezer.

Test Data

Date: _____
Time: _____
Sample Description: _____

Details of Crown Trim

Frame	Weight (grams)	Observations

Appendix C

Soil Sample Analysis Procedure

Particle-size analysis by a modified pipette procedure Indorante, S.J., L.R. Follmer, R.D. Hammer, and P.G. Koenig. 1990. SSSAJ 54:560-563

********** *WARNING - - CHECK FOR ERRORS in this summary* **********

MATERIALS

500 mL Fleakers
watch glasses or corks
10 ml volumetric pipette or pipettor
shaker
dessicator
analytical balance (to nearest 0.001 g, preferably to nearest 0.0001 g)
thermometer
50 μ mesh (270 mesh, 53 μ opening)
100 μ mesh (140 mesh, 106 μ opening or 170 mesh 90μ opening)
Hydrogen perioxide (H_2O_2) for organic matter disolution - optional
2 liters of 10% (100g per liter, mix in 100) sodium hexametaphosphate (Calgon) in distilled water

METHOD

For the following method prepare one blank, which will have all the same treatments, except the soil sample. This is to obtain weight of the Calgon to be subtracted from clay sample.

Monday 1. Prepare soil; crushed and sieved to less than 2 mm

Tuesday 2. Weigh out about 10 g of recently oven dried (cool 15 min in dessicator) soil, obtain weight to 3 decimal places (0.001g)

3. Place soil in 500 ml fleaker

4. Add 10 ml of 10% calgon — top with DI

5. Bring up volume in fleaker to about 150 ml with distilled water

6. Stopper fleaker and shake for 4 hours or overnight (12 hours) — shake mech on hour by hand

7. After shaking, arrange fleakers on table for pipetting

Wednesday 8. Bring volume up to exactly 400 ml with distilled water — top with DI at room temp

9. Determine average temperature of suspensions and cover with watch glasses

10. One fleaker at a time, remove watch glass, cap with stopper and shake vigoursly by hand for 20-25 s insuring that no soil adhered to the bottom of the container. Replace cork with watch glass.

11. Note time started first fleaker.

12. Shake other fleakers at approximately 2 min intervals, the time required to draw and dispense a sample when they are ready.

13. After waiting the appropriate time (Table 1) carefully insert pipette to 5.0 cm and withdraw 10 ml of sample in 15 s. Also do the blank with Calgon only. → Stokes law 2μm ρ_s=2650 ρ_l=1000

14. Discharge pipette into a tared weighing dish (tared to nearest 0.001 g or better).

15. Oven dry samples at 105°C for 24 hours, cool and desicator and weigh. **Clay weight is this sample minus the blank minus the tare.**

16. For sand content wash the remaining sediment through the 50μ mesh. Collect sand from screen into tared Al pan, oven dry and weigh.

Calculations:

Check pipettor to determine true volume transfer by weighing 5-10 ml transfers on an analytical balance. Weigh immediately after each transfer to avoid evaporation. Use temperature of water to determine true volume.

Report; temp., mean mass and standard dev., and calculated pipette volume.

%sand = 100 x (sand weight/total soil weight)

%clay = (clay weight) x (400 ml / pipette volume) x (100/total soil weight)

don't forget to have subtracted calgon blank mass from clay sample.

don't forget to have calculated true pipette volume

don't forget to have used oven dried soil weight

% silt = 100 - (%sand + %clay)

$0.00751 - 0.03790 \times (40\%) \times \frac{22}{10.09}$

Stoke's Law

This is to determine the time to wait prior to pipetting a sample as required in method #13.

$t = 18\ h\ n / (d^2\ g\ (p_s - p_l))$

t = time in seconds
h = sampling depth (m)
d = particle diameter (m)
g = acceleration due to gravity (m/s^2)
p_s = particule density (kg / m^3)
p_l = liquid density (kg / m^3)
n = viscosity of water (kg/m s)

54

Appendix D

Mechanical Harvester Evaluation Test Procedure

October 18, 1999

Test Procedure 9942-02

Test Objective

The objective of this test procedure is to collect engineering and operator observations of the Weening Brothers Manufacturing, Ginsenger harvester and the Bartschi FOBRO Super HD Lifter/Shaker harvester. The harvesters will be operated at the Blue Hills Herb Farm in fields of two year old and three year old plants in both sandy loam and clay loam. The fields will be the same fields that were used for the manual diggings.

Test Equipment

- 100' tape measure
- watch with a second hand
- optical tachometer
- tape measure
- wood barriers made from 1 by 10s with a length of 1650 mm
- 2 spades
- flat blade shovel
- sifting box
- small paint brush
- 15 large ziplock bags
- black marker
- packing tape and tape gun
- cardboard box
- camera and film
- video camera
- video tape

Test Set Up

Test Procedure

1) Record in the Data Sheets the date, time, plant age, field soil type and soil moisture conditions.

2) Record tractor make, model, engine horsepower, tire size and tire condition.

3) Record the harvester type.

3) Record to what extent the plant tops have been removed.

4) When the harvester is operating record the tractor speed, the PTO rpm, how hard the tractor is working, how the soil is being handled and the condition of the roots at the surface. Tractor speed can computed using the 100' tape measure and a watch with a second hand. The PTO rpm maybe available from the tractor or measured using an optical tachometer. Ask the farmer for their assessment of the harvester operation. Take photos and video recordings during harvesting. Record modifications required by the harvester.

5) Select three random locations which have been harvested.

6) Insert wood barriers to enclose a rectangular area 300 mm long and the width of the harvester.

7) Using spades and the flat blade shovel remove the loosened soil between the barriers. Sift the soil through a sifting box and collect the root fragments.

8) Label a large ziplock bag with the date, plant age, field soil type and replicate. Using the paint brush, remove as much soil as possible from the root fragments. Place the cleaned fragments in the labelled ziplock bag. Force as much air as possible from the bag. Close the bag and seal with packing tape. Place filled bag in a cardboard box for transport to the university.

9) Measure and record the harvesting depth.

10) Return the excavated soil.

Test Data

Date: _____
Time: _____
Plant Age: _____
Soil Type: _____
Soil Moisture: _____

Tractor
Make: _____
Model: _____
Engine HP: _____
Tire Size & Condition: _____

Harvester Type: _____

Plant Topping Observations

Harvesting
Tractor Speed: _____
PTO RPM: _____

Engineering Harvesting Observations

Farmer Harvesting Observations

Harvesting Depth
Replicate 1: _____
Replicate 2: _____
Replicate 3: _____

Required Harvester Modifications

Appendix E

Travel Observations

Travel Notes

August 25, 1999

Mr. Bob Merrell
KPR Incorporated
P.O. Box 608, 375 West Avenue "D"
WENDELL, IDAHO 83355-0608
Tel. (208) 536-6601

We met with Mr. Merrell in Pasco, Washington prior to going out to the field to look at some equipment. Mr. Merrell noted that he has AMAC machines harvesting E. purpurea at Trout Lake Farms, Wilcox Pharmaceutical Products and in California.

Mr. Merrell discussed the operation of the AMAC G-2 harvester. The machine has carrot pins at the front of the machine that can be rotated up or down to decrease or increase the digging depth. A positive feature of this design is that if the carrot pins get into the subsoil and get bent then they can be easily replaced.

Vic discussed the requirements of our growers. Many growers are just experimenting. The planting methods are very different between growers: some growers have single rows and others have multiple rows, raised beds versus flat beds, most Saskatchewan growers are organic growers.

Mr. Merrell reviewed the pictures we had of plants and roots in Vic's field. He was not concerned about harvesting the roots.

Mr. Merrell noted that AMAC and Grema? are the largest manufactures of root digging equipment. Another expensive root digger is Vogal?.

Mr. Jim Clostameyer
Near Pasco, Washington

Mr. Clostameyer is a grower northeast of Pasco who grows 1200 acres of carrots, 400 acres of bulb and pearl onions and a few acres of beans for crop rotation. The soil was very light and very fine (like flour). The soil had no stones. The area is a dessert and crops are grown under irrigation.

Mr. Clostameyer has four machines. All of the machines are more than 10 years old. The oldest machine is an E2 model. The two next oldest machines are D2 models. The newest machine is a G2 model. The D2 model is capable of 6 to 7 acres per day. The G2 model is capable of 20 acres per day. The minimum harvesting width is 1.5 m. The D2 models require a 60 hp tractor. Slicer carrots require a maximum digging depth of about 8" and a John Deere 7800 is used for harvesting. This tractor is front wheel drive has 140 hp. All of the tractor power was not required for harvesting. It was noted that front wheel assist is very useful and significantly reduces the horsepower requirements.

We saw some baby carrots being harvested. The baby carrots were grown in raised beds. The beds were raised about 6" to 8" and about 60" wide. The beds were very straight and very level. Bed preparation is important for top removing using a crowner. Mr. Merrell mentioned a bed shaper by Johnstoe?, California. The bed shaper requires 115 hp.

We had a brief look at a defoliator for removing the tops. It consisted of a rotating drum with paddles or flails attached by a chain to the drum. When the defoliator was operating it would toss the carrot tops about 20 ft into the air.

We saw a crowner complete the top removal after the defoliator had passed over the row. The crowner had a hydraulic pump on the tractor PTO. A motor was located on the top that turned a flywheel about 30" in diameter. Six 6" diameter rubber wheels were in contact with the flywheel. At the base of the rubber wheels were circular cutting blades that crowned the plant. Drums on a manual screw at the back and the front were used to control the cutting elevation. The very flat beds permitted precision crowning. The crowner required an 80 hp tractor.

Mr. Merrell was ask about retrofitting the D2 digger. The carrot pins and shoes would cost $ 900.00 US. Changing the digging chain with a used digging chain was about $ 700.00 US. It was anticipated that a new chain would be much more expensive. Mr. Merrell was ask if AMAC has several versions of the carrot pins. It appears that only one standard version is made.

The digging chains used by Trout Lake Farms for digging echinacea are 42 mm centre-to-centre. The rod diameter is approximately 5 mm. Wilcox Pharmaceutical Products uses a 56 mm centre-to-centre digging chain for echinacea.

Mr. Merrell indicated that the typical travel speed for echinacea harvesting was 3 mph to 4 mph. The carrot harvesting we saw was under 1 mph.

The cost of equipment was briefly discussed. Mr. Merrell has a used D2. The cost of this machine was $ 22,000 US. A carrot crowner would cost $ 11,000 US. Mr. Merrell was prepared to put together a five year lease with a cost of $ 33,000 US * 0.23 per year.

Mr. Merrell mentioned that in California, E. angustifolia growers take two or three green cuts. The green cuts are make with a Gahl? harvester. The crop is windrow, green chopped and sun dried.

Mr. Merrell mentioned a large excellent trade show called the Tulare Show, California in February. The show has 240 acres of displays and 20,000 farmers attend the show.

Mr. Merrell recommended a Milton? planter for echinacea seed.

Mr. Merrell has expertise in irrigation. He said modern pivot irrigation has 18 to 20 psi at the centre post. He noted four key irrigation suppliers including Pearson? and Valbought?.

August 26, 1999

Mr. Beat Hauenstein
Bartschi-FOBRO
Dorf 1, Postfach 1
CH-6152 HUSWIL, SWITZERLAND (headoffice)
Tel. 011 41 41 988-2121
1715 Airpark Drive, P.O. Box 651
GRAND HAVEN, MICHIGAN 49417
Tel. (616) 847-0300

We met with Mr. Hauenstein prior to touring various farms with him. Mr. Hauenstein was raised on

a nursery farm. He lived in the US for 3 years. He is the owner of Bartschi-FOBRO. His focus is export sales and financial operations. The person next to him in the company is responsible for production and sales in Switzerland. The manufacturing strategy they use is called 'Just in Time'. They carry an inventory of parts that are length wise in the machine. When they receive an order for a machine then they assemble the machine. An order can be filled in 10 days. Mr. Hauenstein mentioned that they contract someone to laser cut some of their parts. The company has one mechanical engineer in Switzerland. The US office is only sales.

We discussed using brushes for organic weed control. Mr. Hauenstein noted that brush weeding is not cost competitive with herbicides. Mr. Hauenstein knows John Ascard, Sweden. He mentioned the European Weed Research Society and noted that someone from Laval is very active in the society.

As we discussed weeding, Mr. Hauenstein mentioned that he was aware of bed weeders used in Michigan that are called finger weeders.

We discussed hand weeding which lead to manual harvesting of strawberry plants. Mr. Hauenstein noted that in the design of a harvesting cart if the operator's butt is a few inches above their heels then the cart is comfortable to ride.

Mr. Hauenstein mentioned the trade shows he attends: Agric Technica?, Germany in November, another in Paris in February and Eina?, Balogne, Italy. The show in Italy focuses on small equipment.

Mr. Hauenstein noted that he has sold some equipment to Chile and that Chile is considering echinacea production.

We discussed bed preparation and the need to rotary till and then form the bed.

A seeder mentioned by Mr. Hauenstein was Corneyland - Alad?.

Mr. Hauenstein carries a small tractor, approximately 30 hp, that is used as a hoeing tool.

Tim Crockett (Randy, Dutch)
Washington State Department of Natural Resources
9805 Blomberg St SW, P.O. Box 47017
OLYMPIA, WASHINGTON 98504-7017
Tel. (360) 664-2896

They grow conifers for reforestation. The farm is 240 acres. The soil is sandy with no stones. The plots are very level. They harvest bareroot. The harvesting is generally done in late fall under very wet conditions. Most of their transplants are 2 years old. Despite good rainfall irrigation is used. The irrigation is an effective way to add fertilizer. They have three Super HD Lifter/Shakers and a combine. The Lifter/Shakers ranged in age from a couple years to six years. All of them were in good shape.

A Super HD Lifter/Shaker was operated in a fallow field with a combine behind the Lifter/Shaker. A few weeds were present in the field. The Lifter/Shaker was set for the maximum digging depth which was estimated to be 12". The tractor was about 80 hp however it was not working very hard. The Lifter/Shaker appeared gentle breaking the soil and working the root to the surface. The front blade and the rear fingers of the Lifter/Shaker both oscillate. The ends of the picking fingers on the combine are about 25 mm above the soil surface. The combine appeared to do a good job of lifting the weeds off the soil surface.

It was observed that the leading edge of the Lifter/Shaker was worn from use.

The combine had been modified: a hydraulic ram had been added to the hitch assembly to improve maneuverability of the combine. The load-out conveyor had been shortened.

A wide range of equipment was viewed including bed preparation equipment, seeders, root pruning equipment, a tree sorting line and storage coolers.

They described a process called root wrenching. A U plow is run under the roots about 8" below the soil surface. The root is not cut but the soil is agitated just below the roots. The soil agitation stimulates root development near the soil surface. This process was recommended for echinacea production.

A wrenching tool which was mounted between the front and rear wheels of the tractor was viewed. This mounting arrangement was preferred because the operator can easily steer the tractor. The wrenching tool was about 4" wide.

We also observed their root pruner which was a U plow about 1" thick.

During our travel to our next stop, Mr. Hauenstein noted that the best tractor widths are 1.5m and 1.8m and that the typical tractor speed is 12 to 15 fpm.

D. Wells Farms/D. Wells Nursery
Dan & Diana Wells
P.O. Box 336
HUBBARD, OREGON 97032-0336
Tel. (503) 982-1012

We met with Ms. Wells. They have 120 acres of ornamental trees. The seeds are planted in raised beds (approximately 6"). A Bartschi-FOBRO bed shaper is used to prepare the beds. The soil was clay. The beds seemed reasonably soft but the driveway was very hard. Most of the trees are harvested after 2 years. We saw some maples that were broadcast seeded on the top of the bed and covered with saw dust.

It was noted in our conversation that a laser scraper machine had been used to level their fields.

They use a Super HD Lifter/Shaker. The machine we saw was 2 years old. It was observed that the machine had some bearing damage. Ms. Wells thought that the machine can dig 8" to 10" deep.

Conversation with Mr. Dan Wells at the Farwest Show

Mr. Wells digs 100 acres per year. Often digging is done under very wet soil conditions.

Mr. Wells uses the Super HD Lifter/Shaker for 4 years and then replaces it because it is worn out.

The Super HD Lifter/Shaker can dig 12" deep. Mr. Wells uses an 80 hp four wheel drive tractor. Book weights are added to the front of the tractor because the Super HD Lifter/Shaker is very heavy. The Super HD Lifter/Shaker is capable of 145,000 plants per day with 12 workers lifting the plants out of the soil.

Mr. Wells has tired an Ag Dol? root harvester. It went 10 ft and broke. He is not aware of any other

root harvester manufacturers. He is please with the service from Bartschi-FOBRO.

We discussed topping of the plants. Mr. Wells suggested an experiment to compare: leaving the tops, harvesting the plants and cutting the tops later with mowing the tops and harvesting the roots.

According to Mr. Wells, Mr. Hauenstein acquired the company from Bartschi about four to five years ago.

Heritage Seedlings Inc.
Mark & Jolly Krautmann
4199 75th Avenue SE
SALEM, OREGON 97301-9242
Tel. (503) 585-9835

Frank the farm manager gave us a tour. Heritage Seedlings has 140 acres that is a former river bed. The soil is sandy but with lots of round stones. Many of the stones have been removed.

Prior to seeding, four disks are run down the row to collect the soil into a bed. A bed shaper is then applied to form the bed.

Frank took us to their machinery depot. Heritage Seedlings has a Super HD Lifter/Shaker but it is not used because it is too wide for the bed. Frank prefers a competitors machine (Lundeby, Tolna, North Dakota) that is lighter. The Lundeby has a stationary front blade but the rear fingers oscillate up and down to lift the roots. The front blade of the Super HD Lifter/Shaker oscillates.

We saw the Bartschi-FOBRO Oscillator Side Lifter/Shaker. It is a very heavy machine. Mr. Hauenstein discouraged using this machine for harvesting echinacea. He thinks it will dig deeper than needed. Frank uses it for digging trees greater than 5 ft tall.

We discussed root wrenching. Frank indicated that it was important for encouraging root development near the soil surface.

Heritage Seedlings uses a transit to establish their very straight rows.

Heritage Seedlings has some brush weeders of Bartschi-FOBRO but they are not using them.

We viewed some seeding equipment, a German Egedal harvester and other machines. The Egedal harvester was very expensive and did not work well.

August 27, 1999

Mr. Kevin Ernst
Trout Lake Farm Co.
149 Little Mountain Road
TROUT LAKE, WASHINGTON 98650
(509) 395-2025

Trout Lake Farm is a grower and primary processor of organically grown herbs. The site we visited is approximately 500 acres. The main production site for E. angustifolia is at Ephrat, Washington. The

farm at Ephrat is 1100 acres. Both farms utilize irrigation. Three year old E. Angustifolia plants are harvested. All of their production is organic. The primary reason for the visit was to discuss marketing of echinacea. Mr. Ernst was reluctant to discuss many aspects of production.

We did observe a field of E. purpurea cultivated by Trout Lake Farm. The plants were in single rows with approximately 24" row separation. No special bed preparation was evident. The soil was sandy. It appeared that one strip in the field had been harvested. The harvesting width was 54".

Mr. Ernst thought there was no right way to grow echinacea. It was agreed that single rows with space between the rows for air flow will reduce disease. Mr. Ernst indicated that the most common harvesting method is with a U plow. He thought that root wrenching was a good idea.

Trout Lake Farm utilizes a barn with a screened floor for drying. Air is forced through the roots. Propane burners preheat the air. Mr. Ernst seemed to indicate a maximum drying temperature of 40°C. The roots are turned manually.

Mr. Ernst mentioned that echinacea is highly variable. Trout Lake Farm is doing some plant breeding/selection.

Trout Lake Farm does purchase dry root. Trout Lake Farm is capable of cutting, sifting, grinding to #60 mesh dry root and making tea bags. Trout Lake Farm is a wholesaler. Trout Lake Farm does their own testing but generally buyers will repeat the tests.

Red clover is used in their crop rotation. The blossoms are cut and sold.

Mr. Ernst estimated world wide production of E. angustifolia at 1000 acres.

August 28, 1999

Farwest Show
Oregon Convention Center
Portland, Oregon
August 27-29

The show had 650 exhibitors and 870 booths. The show was very well attended.

Bartschi-FOBRO and one other company, GK Machine, Donald, Oregon, were the only companies offering root lifting equipment. The machine offered by GK Machine was a side lifter and was judged not to be suitable for echinacea.

August 31, 1999

Wes
R. & W. Equipment Limited
R.R.1, Cookstown ON L0L 1L0

We met with Wes to discuss the ASA Lift carrot harvester.

September 1, 1999

Mr. Fred Weening
Weening Brothers Manufacturing Inc.
Wist Road, R.R. #1 KETTLEBY ONTARIO L0G 1J0
(905) 775-3839

Mr. Weening and two other people own a fabricating shop that employees about 10 people. They are also a dealer for Thomas potato harvesters. They are located in the Holland Marsh north of Toronto. The soil is fertile and sandy. Mr. Weening started by working on a family vegetable farm. In 1986, he decided to start building harvesting equipment. Onion harvesters and carrots harvesters were the first harvesters they built. During the past 3 years they have supplied ginseng harvesters and during the past year they have supplied echinacea and garlic harvesters.

Mr. Weening reviewed the photos. He thought the roots of the echinacea were exactly the same as horseradish roots. A horseradish grower who reviewed the photos later in the day also thought the echinacea roots looked exactly like horseradish roots.

Mr. Weening showed us their basic ginseng harvester. It has a U plow at the front. The machine is capable of digging 12" deep but the digging depth depends directly on the tractor hitch height. The harvester has a single digging chain. The digging width is 64". Some models have four (two per side) three sided pulleys that provide agitation. Other models have rollers connected by an eccentric drive to a hydraulic motor that provide agitation. The rear tires are curved under the back of the machine to minimize overall machine width. The tire inside width is 63". The harvester has a capacity of 3 to 4 acres per day in ginseng and 2 acres per day in echinacea. A 60 to 70 horsepower tractor is required and four-wheel-drive is preferred. The harvester can be transported with a 20 ft goose-neck trailer. The harvester is very similar in overall appearance to the Gallenberg harvester. The disadvantages of the Gallenberg harvester are a weak hitch, hook chain and an undersized horizontal tube at the front of the harvester that is part of the hitch. Power for the digging chain comes from the tractor PTO. A new harvester with belted chain costs $ 15,000 to $ 16,500. A used harvester costs $ 11,000. The harvester does not have a cross conveyor and drops the crop back onto the ground. The advantage of dropping the crop on the ground is that the person picking the crop can shake the dirt out of the roots. With a cross conveyor or boom more dirt lumps and stones are collected. The extra dirt can lead to more spoilage.

Two options exist for the digging chain: hook chain or belted chain. The hook chain costs $ 2,000.00 and requires frequent replacement (every year). The belted chain is gentler with the crop and reduces the gap between the chain and the stationary sides. Further, a 64" digging width uses 2 hook chains. This requires a centre divider which creates a dead spot in the centre. Chain comes in a centre-to-centre distance of 28 mm to 56 mm. The rod diameter is 12 mm. Mr. Weening thought a centre-to-centre distance of 36 mm might be best for echinacea.

Canadian Imperial Ginseng

Canadian Imperial Ginseng has 200 acres of echinacea.

Canadian Imperial Ginseng had two Gallenberg harvesters sitting in their yard. Also, they had a side lifter similar to the Bartschi-FOBRO Oscillator Side Lifter/Shaker. The side lifter was lighter in construction than the Bartschi-FOBRO side lifter. We noted that a harvester similar to the Gallenberg harvester was begin fabricated in the shop.

We spoke with Peter, the person doing the fabricating. He said they dig 12" deep in sandy soil to harvest echinacea. Peter commented that a roller (approximately 6" diameter) mounted above the digging chain damaged the roots. Mr. Weening commented later that the roller did not work because it was probably resting on the crop rather than being supported above the crop.

Lucas Farm

This farm grows ginseng and echinacea. The land is very sandy. The farm was harvesting E. purpurea on the day we visited.

We started our tour by viewing the washing and drying process. The roots arrived from the field in wooden boxes approximately 3 ft by 2.5 ft by 2.5 ft deep. The roots had approximately 1.5" of stem. It appeared the harvesting depth was about 6". The roots were dumped onto a sorting line and about five people sorted through the roots removing weeds and dirt. The roots were then conveyed up into a tumbling drum which was open on both ends. A bank of spray nozzles were mounted inside the drum at the top and along the length of the drum. The nozzles sprayed water down at an estimated pressure of 40 psi. One person was at the bottom of the drum and used a hooked tool to assist the roots out of the drum. The roots fell onto another conveyor and went to another station where two people put the roots into drying trays. The trays were about 3 ft square and 4" deep with a stainless steel screen at the bottom. The screen had about 1/8" holes. The trays were stacked about 6 ft high and loaded by fork lift into drying sheds. The drying sheds were about 25 ft long, 6 ft wide and 6 ft high. The floor of the drying shed was perforated metal that was identical in appearance to the non-slip perforated metal floors sometimes used at the entrances of buildings. The sheds had a furnace and a fan at the end opposite the door. When the sheds are drying probably air is forced out through the floor.

Our tour then proceeded to the field to see the harvesting. The farm has about 140 acres of E. purpurea. The plants were grown in single rows without raised beds. The first harvesting operation was to remove the tops at about 8" above the ground. The tops were collected. The tops were harvested twice per year. The second harvesting operation was to cut the tops so no green was left on the plant. This cut was close to ground level. A metal flail was used. The flail was a rotating drum with metal buckles about 2" square on chains about 4" long. Following removal of the tops, a small tractor (approximately 40 hp) pulled a plow with shovels down the tractor tire paths to loosen the soil in the paths prior to harvesting. The plow had disks that went on each side of the row. A Weening Brothers Manufacturing ginseng harvester was used to harvest the E. purpurea. The harvester would dig 3 rows at a time. It was estimated that the digger was going 6" deep. The harvested roots were dropped on top the soil. The roots appeared clean. It was estimated that 15 people were collecting the roots into wooden baskets.

Mr. Peter White
Agriculture Canada

Delhi Research Station
P.O. Box 186
DELHI ONTARIO N4B 2W9
(519) 582-1950

We looked at three different harvesters for lifting plants out by their tops. None of these harvesters appeared suitable for echinacea.

We also saw a belly mounted weeding tool that Mr. White said was excellent for weeding row crops.

Mr. White does not work with echinacea. He recommended Mr. Bob Roy ((519) 582-1950) to discuss agronomy and Mr. Mike Columbus ((519) 426-7120) to discuss marketing.

Mr. Jeff Moggach
Kytes Horseradish

Mr. Moggach reviewed the photos taken at Vic's farm of echinacea roots. He thought the roots of the echinacea were exactly the same as horseradish roots.

This farm started with a Thomas potato harvester and modified the harvester for horseradish. The harvester was old but was still being used for harvesting. The harvester dug two rows per pass. The important modifications to the harvester were reinforcement of the front and sides and a special digging blade. The sides were originally 3" channel and were reinforced with 5" square tube. The horizontal tube that connects to the hitch was replaced with a larger tube. The digging blade had two V shaped points that protruded about 15". A space existed between the points in the middle. Harvesting was a single pass. The harvester would go 18" deep. The soil was sandy. The harvester had hooked chain.

Following the visit to Kytes Horseradish we saw two other large harvesters with multiple conveyors and additional features. These harvesters were being used in onions and garlic.

Mr. Weening suggested a forage harvester for removal of the tops a few inches above the soil surface. It was noted that a forage harvester requires level ground.

Mr. Weening commented that following the first digging chain in the harvester a star table is very effective in removing the remaining dirt. He called the star table a dirt eliminator. A star table is a collection of rotating square rods with rubber stars inserted on the axis of the rods. The stars rotate with the rods. The stars are about 4" in diameter, 1/2" thick and separated by 2 1/2".

It was noted that 99% of ginseng is manually picked off the field after harvesting.

A typical drum washer would be 4 ft in diameter and 12 ft long with a stainless steel screen around the periphery. The holes in the screen are about 1/4" diameter.

Mr. Weening suggested that the crop be take from the field using a mobile hopper. The roots could be dropped in a pit in the ground with circulating water as a prewash.

Mr. Weening noted that a flume washer is very effective for removing dirt clods and rocks. The roots are conveyed through a flume of water. The roots float but the dirt and stones sink. At the end of the day the flume is drained and the dirt and stones are shovelled out of the flume.

At the very end of the day we saw a short single row harvester Mr. Weening was making for a small potato grower. This harvester was a new product for Mr. Weening. The digging width was 30". A belted chain was being used. The chain had 7/16" rods and 1 1/8" centre-to-centre distance. The harvester was lightly constructed. The harvester had mechanical belt agitation. The harvester mounted on a tractor three point hitch and used the tractor PTO. The harvester costs $ 3,900.00. One harvester was to be in the field on September 7.

September 3, 1993

Mr. Rueben Hintz & Mr. Jim Gudanski
Gallenberg Equipment, Inc.
W9112 Cherry Rd.
ANTIGO WI 54409
(715) 623-3754

The first stop was to see a used ginseng harvester that was a windrower. The machine looked in good condition. It had hooked chain. The front blade was worn-in about 1/2". The asking price on this machine was $ 7,000.00 US.

Gallenberg will sell used equipment on behalf of the farmer. Used machines typically cost $ 5,000.00 US to $ 8,000.00 US. The cost to change from hook chain to belted chain is about $ 4,000.00 US. The change involves changing the sprockets and the belt. Belted chain is much more durable than hook chain.

The Gallenberg ginseng harvester has a digging width of 65". The tractor has a centre-to-centre tire spacing of 72". The digging depth is 8" to 9". Ginseng is grown in raised beds. It was suggested that we consider digging out the soil where the tractor wheels will pass to create a raised bed effect. The cost of a new ginseng harvester (windrower) is $ 14,000.00 US to $ 15,000.00 US.

Richard Renee Farm

This farm was washing ginseng when we arrived. The roots are collected in the field in a truck box. At the washing site the roots are dumped onto a flat bed that has eight 3 ft by 3 ft by 2 ft deep boxes. The boxes are side by side in two rows of four. Each box is lifted with a fork lift and dumped into a hopper. The roots are conveyed up into a cedar drum. A spray line was installed in the top of the drum and along the axis of the drum. The cedar drum was open at both ends. The drum was made from lats about 2" wide and separated by about 1/4". The drum was 3 ft in diameter and 8 ft in length. The drum sloped down. The roots tumbled down the drum as the drum turned. The pitch of the drum was adjustable to control the speed of root travel through the drum. When the roots exited the drum they fell into a water flume. Rods about a 1/2" in diameter skimmed through the flume and moved the roots through the flume and onto a conveyor and into a wagon. A conveyor in the bottom of the flume moved stones in the opposite direction of the roots and conveyed the stones out of the flume. The roots appeared well washed. Three people were doing the washing. Later in the day we saw a washer with a mess screen. It was noted that the fine ginseng roots will fall through the mess screen.

It was mentioned later that ginseng roots are somewhat fibrous, strong and able to take a fair amount of agitation during harvesting.

The harvester used by the farm was a complete harvester which included a windrow and additional equipment to remove dirt and trash. The harvester was able to harvest 2 acres per day of ginseng. The yield is 2000 to 3000 lb of dry root per acre. The windrow alone requires 50 to 60 people to pick up the roots. The complete harvester requires 7 people. People in the field have the capacity to select the roots, leave the trash and shake the dirt from the roots. On a complete harvester when the roots exit the digging chain they pass over an 8" wide jet of air. The roots are caught by a solid belt with 1" high rubber fingers then augured up slightly and then dropped onto a star table. Following the star table the roots drop onto another conveyor and are moved into the truck.

At the office, Mr. John Kryka joined us. Mr. Kryka is the chief engineer for Gallenberg. We discussed the Plantation Medicinal harvester that Gallenberg had built. A root lifter was used in advance to loosen the soil and start the roots moving up and out of the soil. The digging chain was 7/16" by 32 mm belted chain. The roots dropped from the digging chain to a secondary chain that was 1/2" by 1" fertilizer chain. The roots fell off the secondary chain and onto a cross conveyor for loading into a truck. Mr. Kryka has not spoken with Plantation Medicinal to inquire how the machine has been operating.

Mr. Kryka showed us a single row windrow that was used for digging wild ginseng in the woods. It was necessary to loosen the soil along the digging path before the windrow dug the roots. Mr. Kryka also showed us a standard windrow with a three-point hitch mount.

Gallenberg does many custom built machines and they build some large potato harvesters.

We saw a very large custom horseradish harvester that had a digging width of 13'. The digging blade was a straight blade. It was noted that a straight blade operates best in clay soils. A blade with points operates best in sandy soil.

Appendix F

Harvester Brochures

AMAC

AMAC G2

TWO ROW TRAILED HARVESTER

One of the most recent developments in harvesting-technology is the AMAC-G2 two row universal harvester.

Over 40 years experience and knowledge have resulted in the solution for end-users in order to meet new standards and requirements.

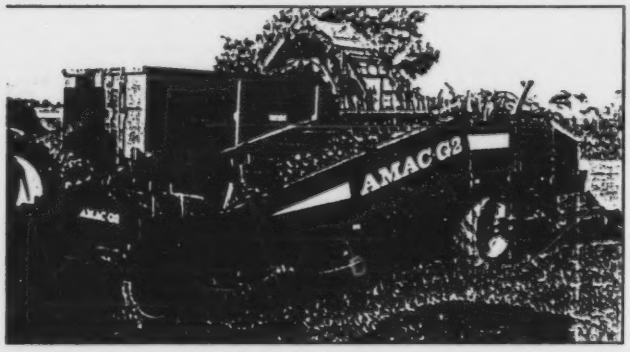
AMAC B.V. is using advanced design- and production technologies for an almost complete range of harvesting and storing equipment for potatoes, root- and bulbcrops, etc.

The AMAC-G2 is an efficient, universal harvester, and meets the highest quality standards of end-users, as well as safety regulations.

It will be worth contacting us for a demonstration in your particular circumstances and see what we mean.

FEATURES

- Portal-axle with hydraulically adjusted levelling and steering
- Chassis with large, clear area underneath the webs, to eliminate problems with haulm and soil
- Shareholder with special deflection roller

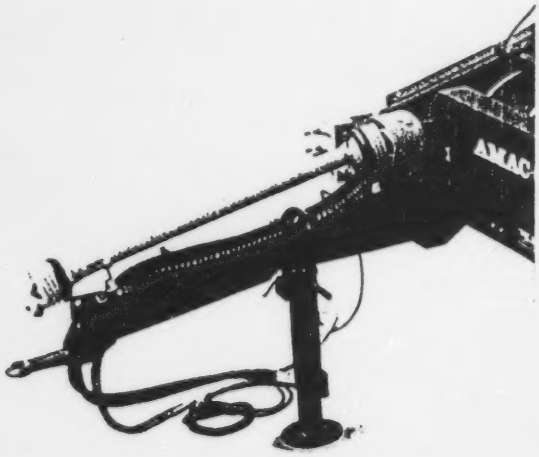


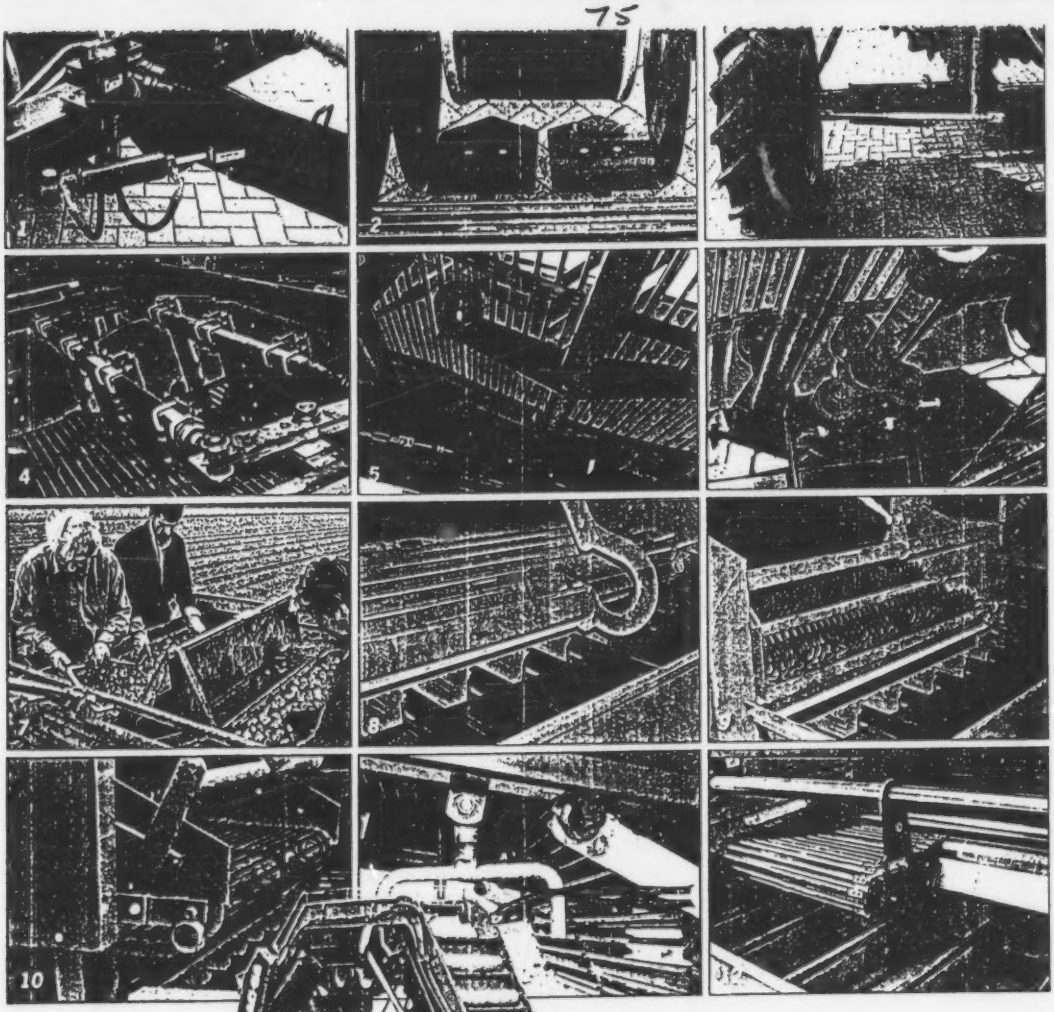
- Diabolo rollers are pendulum-suspended to ensure a constant digging depth
- Wide range of optional extra's available
- 1st haulmroller can be safely cleared by a handle

STANDARD SPECIFICATIONS

- Universal share-adjustable from 30" to 36" rows
- Haulm insert wheels: on left/centre/right of intake
- Diabolo rollers are pendulum-suspended
- Fully adjustable self steering discs
- Three deflection rollers in the 1st web
- Two rotating agitators, V-belt driven, hydraulically adjusted
- Universal web drives with rubber rollers
- First web without, second web with PVC-covered bars
- Six harvesting speeds with alternative drive pulleys
- Two haulm removing rollers, fully adjustable
- Elevator with hydraulic drive unit and fully adjustable in speed and discharge height
- Hydraulically adjusted levelling and steering axle
- Electrically operated control valves
- 5 progress cleaning rollers with 2 half rollers for even loading

1) Hydraulic lane adjustment* / 2) Two piece share with haulm insert wheels, and self cleaning diabolo¬rollers* / 3) Axle extension/ re-enforcement, 36" rows* / 4) Oscillator with hydraulic drive* / 5) Oscillary agitators* / 6) Rotating agitators / 7) Picking-off table* / 8) 5 progress cleaning rollers / 9) Star-cleaning unit* (not for U.K.) / 10) 3rd web in lieu of cleaner-unit* / 11) 1st haulmroller adjustment / 12) 1 m wide elevator, with web and roller* (*= optional)

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AMAC·G2

T E C H N I C A L : D A T A

*Hedge-hog cleaning unit**

*Cage web cleaner**

** = optional*

	G2/1500	G2/1700
Length	8,3 m	8,3 m
Width	2,85 m	3,07 m
Height	3,24 m	3,24 m
Weight	4500 kg	4950 kg
Tyres L	12,5 / 80-18	12,5 / 80-18
R	12,4 x 24	12,4 x 24
Number of sievechaines	2	2
Width of the chains	1,48 m	1,7 m
Sieve-area	7,5m²	8,6 m²
Width of the elevator	0,8 m	1 m
Max. clearance	3,15 m	3,15 m
Min. clearance	1,8 m	1,8 m
Shares	2 x 22 cm	14 - 22 - 14 cm
Discs	ø 60 cm	ø 60 cm
Diabolo's	ø 40 / 61,5 cm	ø 40 / 61,5 cm
Row-distance	70 - 92 cm	75 - 92 cm
Min. tractor HP	55 HP (40 kW)	65 HP (48 kW)

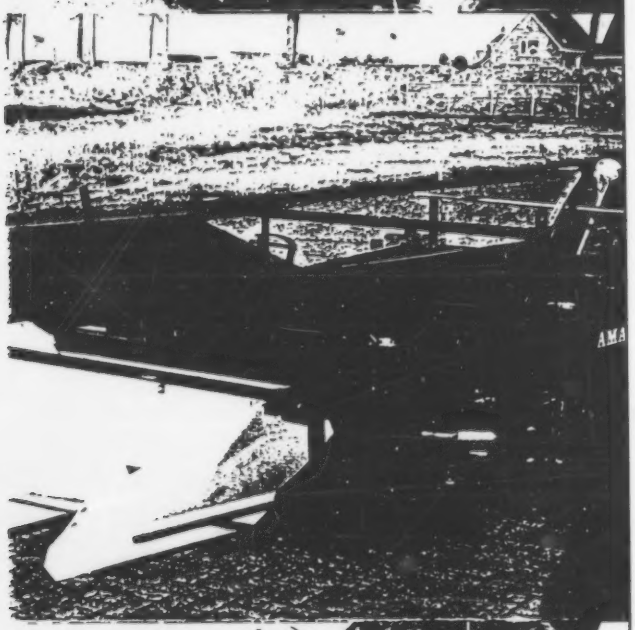
OPTIONAL EXTRA'S

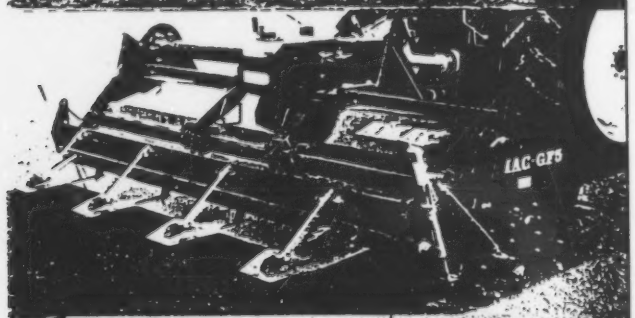
■ Hedge-hog cleaning unit ■ Work- and road-lights ■ Oscillary agitators in 1st web ■ Wheels 11.2 x 24 or 16.00/70 x 20 or 13.5 x 17 ■ Axial-roller cleaning set with 18 pc. rubber rollers (open end) and hydraulic drive ■ Elevator 1 m with PVC-cloth, web for even loading of crop on elevator, and 1 half roller ■ Electric/hydraulic operated lane adjustment ■ Stainless-steel rollers in cleaner unit ■ 3rd web in lieu of cleaner unit ■ Picking-off table, manned up to 4 personnel, hydraulically driven and stepless speed adjustment ■ PVC-cloth with web 36 mm in elevator ■ Oscillator, hydraulically driven and stepless speed adjustment ■ Axle extension/re-enforcement for 36" row distance ■ Self cleaning rubber for 2 diabolo's ■ Share holder weight divider, manually of automaticly controlled ■ Cage web cleaner for 1st/2nd web ■ Support beam for different crop lifting ■ Onion harvesting attachment ■ Onion wind-row pick-up attachment, incl. onion flap, hydraulically operated ■ Beetroot lifting attachment

AMAC

DEALER:

The manufacturers reserve the right to alter specifications etc, at any time without prior notice.





AMAC-ZM

ZELFRIJDENDE WAGENROOIER • SELF-PROPELLED HARVESTER • ARRACHEUSE AUTOMATRICE • SELBSTFAHRENDEN ÜBERLADERODER

Universele rooimachine met 3 zeefbanden, diverse reinigings- en rooisystemen voor 2-, 3-, of 4 rijen, hydrostatische aandrijvingen.

Universal harvester with 3 sieve-webs, several cleaning and harvesting systems for 2-, 3-, or 4 rows, hydrostatic drives.

Arracheuse universal avec 3 tapis, plusient system nettoyage et récolte pour 2-, 3-, ou 4 rangs, transmission hydrostatique.

Universal Rodemaschine mit 3 Siebketten, Mehrere systemen für Reinigung und Roden für 2-, 3-, oder 4 Reihen, hydrostatische Antrieben.

AMAC-VR

ZWADROOIER • WINDROWER • ARRACHEUSE • VORRATSRODER

Uitgevoerd met 2 rooibanden voor uien of aardappelen in 1,42 m of 1,7 m breedte, met schudschaar of rooias.

Equipped with 2 sieve-webs for onions or potatoes in 1,42 m or 1,7 m wide. with oscillating share or diggerbar.

Equiper avec 2 tapis pour des oignons ou pomme de terre à 1,42 m ou 1,7 m, avec socs vibrants ou rouleau d'arrachage.

Ausgerüstet mit 2 Siebketten für Zwiebeln oder Kartoffeln in 1,42 m breite mit Rüttelschare oder Rodewelle.

AMAC-GF5

4-RIJENFREES • 4-ROTARY CULTIVATOR • 4-FRAISE INTERLIGNE • 4-REIHENFRÄSE

Instelbare rugvormer, rijafstand 70 - 75 - 80 - 85 - 90 cm.
Adjustable ridgeformer, row distance 70 - 75 - 80 - 85 - 90 cm.
Tôle butteuse réglable, écartement 70 - 75 - 80 - 85 - 90 cm.
Verstellbare Dammformer, Reihenweite 70 - 75 - 80 - 85 - 90 cm.

AMAC-LK

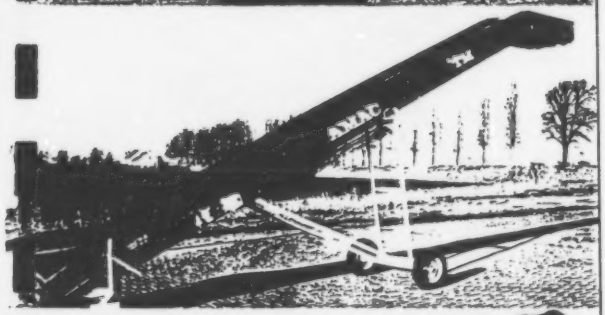
LOOFKLAPPER • HAULMTOPPER • BROYEUR DE FANES • KRAUTSCHLÄGER

2- of 4-rijig, eventueel met loof afvoerband, getrokken of combi.
2- or 4-row, also with side-discharge web, led or combi.
2- ou 4-rang, aussi avec tapis d'évacuation des fanes version trainée ou combi.
2- oder 4-Reihen, eventuel mit Seitenabfuhrband, angehängt oder Combi

AMAC-AK4

AANAARDER • RIDGER • BUTTEUSE • HÄUFLER

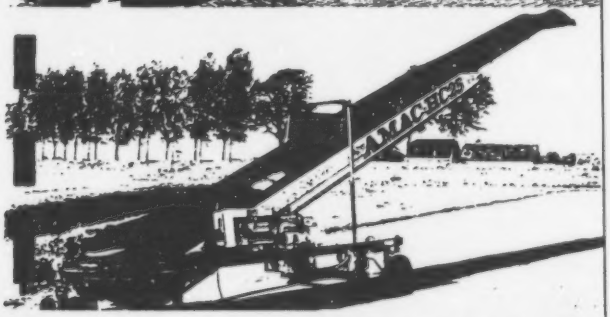
4-rijig met schijven en rugvormer, rijafstanden 75 / 90 cm.
4-Row with discs and ridgeformer, rowdistances 75 / 90 cm.
4-rang avec des disques butteurs, tôle formeuse 75 / 90 cm.
4-Reihig mit Dammformblech, Reihenweite 75 / 90 cm.



AMAC-TM

OPVOERTRANSPORTEUR • ELEVATOR • ELEVATEUR • HÖHENFÖRDERBAND

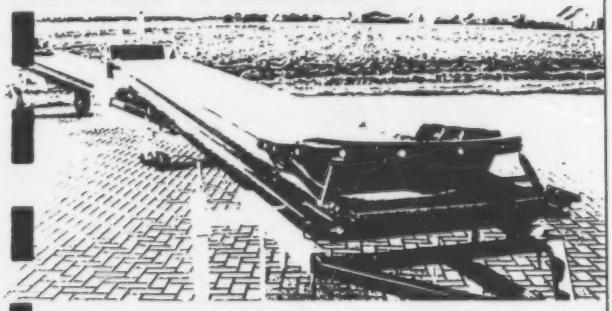
Bandtransporteur met verstelbare hoogte en knik, lengte 8,6 / 10 m.
Elevator with adjustable height and luffing head, length 8,6 / 10 m.
Elevateur avec hauteur d'élévation et col de cygne réglable, longeur 8,6 / 10 m.
Förderband mit verstellbare Förderhöhe und Winkelabgabe, länge 8,6 / 10 m.



AMAC-HC

BOXENVULLER • STORE-LOADER • SAUTERELLE • HALLENFÜLLER

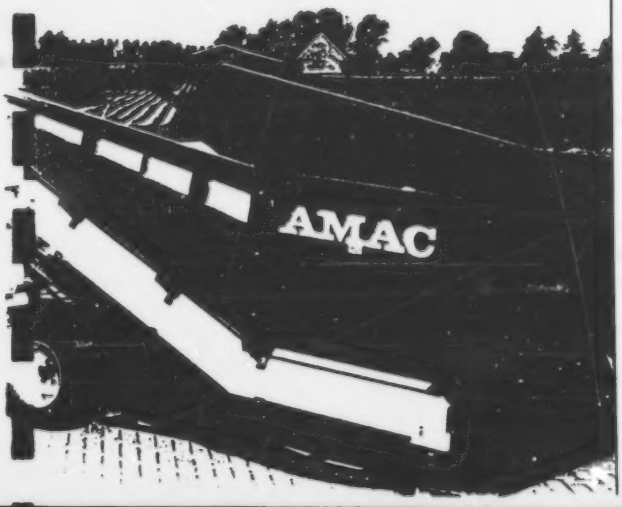
Diverse uitvoeringen met een zwenkbereik van 16 - 30 m.
Low intake, types with swinging reach of 16 - 30 m.
Hauteur de chargement faible, modèle avec balayage de 16 - 30 m.
Niedrige Einschütthöhe, Ausführungen mit Schwenkbereich von 16 - 30 m.



AMAC-DT

DUO-TRANSPORTEUR • DUO-CONVEYOR • TRANSPORTEUR-DUO • DUO FÖRDERBAND

Vlakke band met meelopende zijkanten, l = 2 x 6 / 2 x 8 m, b = 65/80 cm.
Flat-belt with moving sides , l = 2 x 6 / 2 x 8 m, w = 65/80 cm.
Bandes plane avec parois en auge, l = 2 x 6 / 2 x 8 m, l = 65/80 cm.
Flaches Band mit mitlaufende Seiten, l = 2 x 6 / 2 x 8 m, b = 65/80 cm.



AMAC-BLX

STORTBAK • RECEPTION HOPPER • TREMIE DE RECEPTION • ANNAHMEBUNKER

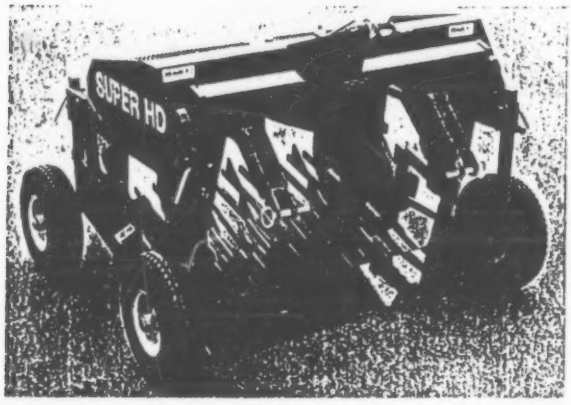
Stortbakken met unieke hydraulische aandrijving, variabel reinigingssysteem, inhoud 7,5 tot 16 m³, eventueel met leestafel en/of voorsorteerder.

Reception hoppers with unique hydraulique drive, variable cleaning system, capacity 7,5 - 16 m³, also with picking table and/or pre-grader.

Trémies de réception avec commande hydraulique, déterreur avec callibrage réglable, contenance 7,5 - 16 m³, option table de visite ou/et dégrenailleur.

Annahmebunker mit einzigartigem hydraulischer Antrieb, variabler reinigungsanlage, Inhalt 7,5 - 16 m³, auch lieferbar mit Verlesetisch oder/und Vorsortierer.

FOBRO Super HD Lifter/Shaker



The FOBRO Super HD lifter/shaker is built for heavy duty purposes: for harvesting any bareroot stock in nurseries.

Other applications would be asparagus, herbaceous and perennial plants, strawberries and many more.

Technical Information

FOBRO Super HD	type 1350	type 1500	type 1700
working width	135 cm / 53"	150 cm / 59"	170 cm / 67"
wheel track	150 cm / 59"	180 cm / 71"	200 cm / 79" (appr.)
weight	900 kg / 1984 lbs.	935 kg / 2061 lbs.	1025 kg / 2061 lbs.
horsepower required	44 kW/60 HP	48 kW/65 HP	51,5 kW/70 HP
clearance	95 cm / 37,4"		
P.T.O. shaft	540 or 1000 rpm working rpm: 350-450		
working depth	maximum 35 cm / 13,8"		

Bärtschi-FOBRO AG
Dorf 1 | Postfach 1 | CH-6152 Hüswil/Schweiz

FOBRO Super HD Lifter/Shaker

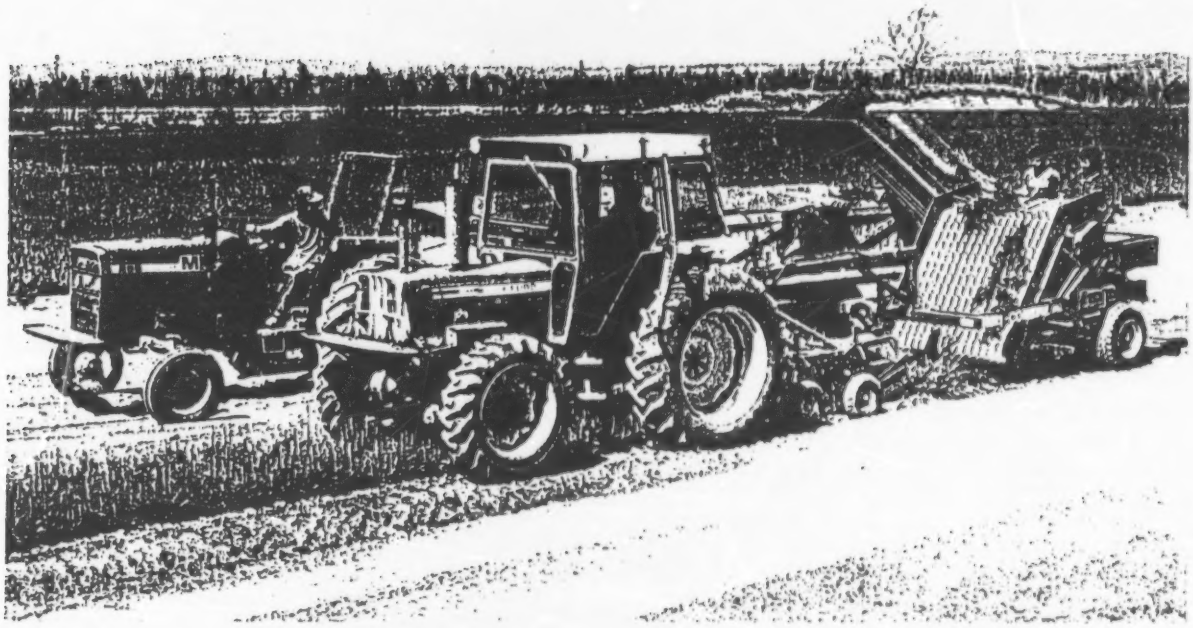
Standard equipment	Your advantage
In driving direction oscillating undercutter blade with lifting/shaking bars	Less traction or horsepower needed, the blade cuts itself through the ground. The soil is not scooped up and compacted as with rigid blades. Therefore you harvest more of the roots. More roots = better quality = satisfied customers = better price = more profit!
Second rear shaker right after the first lifting/shaking bars	This ensures a gentle and soil free lifting of the plants.
Four individually adjustable wheels (no tools needed for the adjustment)	Provides good stability. The machine keeps its working depth exactly.
Two heavy flywheels	Provide smooth operation.
Replaceable wear-blades	Less maintenance cost.

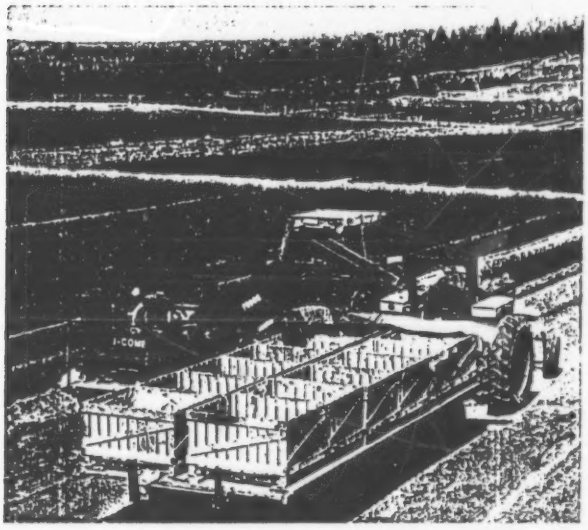
Optional equipment	Your advantage
Horizontal root pruning blade	In driving direction cutting root pruning blade provides a clean cut, harming of the plants is reduced to a minimum. No drag or build-up of uncut roots on the blade.
Vertical root cutting discs	Horizontal root growth can be controlled with these adjustable cutting discs. The swinging of the discs makes the steering of the machine easier and stops the sticking of wet and heavy soil on the discs.
Side guide plates	They provide a windrowing effect and protect the plants while the machine moves forward. At the same time they keep your track clear for lifting and harvesting the adjoining bed.

Bärtschi-FOBRO AG
Dorf 1 | Postfach 1 | CH-6152 Hüswil/Schweiz

Spezialgeräte für Gemüsebau, Baumschulen und Sonderkulturen | Machines spéciales pour les cultures maraîchers, pépinières et l'horticulture | Specialty Equipment for Nursery, Vegetable and Horticultural Crops

FOBRO Combine/Harvester





The FOBRO Combine/Harvester build to pick up and convey into bins, boxes or trailers any bareroot stock, seedlings or transplants grown in beds, rows or broadcasted. Hardwoods and conifers, as well as most shrubs, berries and perennials are picked up and conveyed gently. The digging, lifting and shaking is done either with the well known FOBRO SUPER HD lifter/shaker or its new companion the FOBRO 2000 lifter/shaker.

Versatility to be adapted:
The FOBRO Combine/Harvester can be individualized to fit your production methods. It can lift any row configuration, even broadcast seeded beds.
No matter which handling system you use, bagging, bundling or bulk, the Combine will be able to handle any existing method.
If you wish to do some grading right in the field while harvesting is done, there is different length of grading tables to be integrated depending on various factors such as plant material, sizes to be graded, availability of personell and other pertaining information.
Due to the vast possibilities on how to harvest Plants and the valubal experiance that we were able to gather through contacts over decades with hundreds of nurseries world wide, you might consider to share your needs with us to the benefit of both of us.
Please call for more information. Thanks!

Bärtschi-FOBRO AG
Dorf 1 | Postfach 1 | CH-6152 Hüswil/Schweiz

FOBRO Combine/Harvester

Standard features	Your advantage
Adjustable quick coupling system to attach or detach the Combine/Harvester from the Lifter/shaker	This allows the use of the Lifter/shaker or the Combine/Harvester in combination or independently. On some species the Combine can harvest more than two times faster than lifters can lift and shake the plants.
Goose-neck coupling	Very tight turning radius for easy maneuvering
Unique Pick-up system with special belts and tines that retract before the drop off point	The plants are not grabbed by belts and pulled out of the ground, they are picked up very gently and no damage can occure. The tines retract prior the drop off point, so that no plants can be tangled and twisted around shafts.
Bulk-version	
Retractable conveyor for side delivery to fill two bins loaded side by side on trailer	Tractor and trailer can pass underneath for non-stop operation. The two rows of bins loaded on the trailer can be loaded easy without a lot of hand filling. For road transport the side conveyor can be turned longways in seconds.
Electro-hydraulic control unit	Controls of pick-up depth and speed, position and speed of side conveyor, as well as drop off point for far or close bin can be mounted where best visibility is secured, either on tractor or on the Combine/Harvester working platform.
Grading/orienting-version	
Flatt, slow moving, (bed wide) belt	Possibility to orient (roots all in same direction) and grade on belt depending the plant variety lifted.
Rear and side platform for personnel and bins	Spacious working area to handle at least two bins and enough room for two to four employee.
Electro-hydraulic control unit	For pick-up depth and speed as well as belt speed to be mounted either on tractor or Combine/Harvester working platform.
Optional features	**Your advantage**
Steerable dual axle	Very usefull where tight field edges are given. No plants are overrun, machine can be ligned up precisely and if needed straightened out.
Canvas canopy	Depending your wheater condition the canopy will protect against sun, rain or wind and cold.
Run off sledges to set bins on the ground during operation	No need to stop and change bins where long field runs are given. The filled up bins are rolled off the rear end and set on the ground for continious operation.
Watering devices, bagging units and other usefull options	There are many right ways to harvest plants but only one way will fit your nursery best. Lets talk about the very best version of FOBRO Combine/Harvester for you. We look forward to analyse your given facts and offer you the best adapted machine to help you harvest more quality, happy and satisfied customers.

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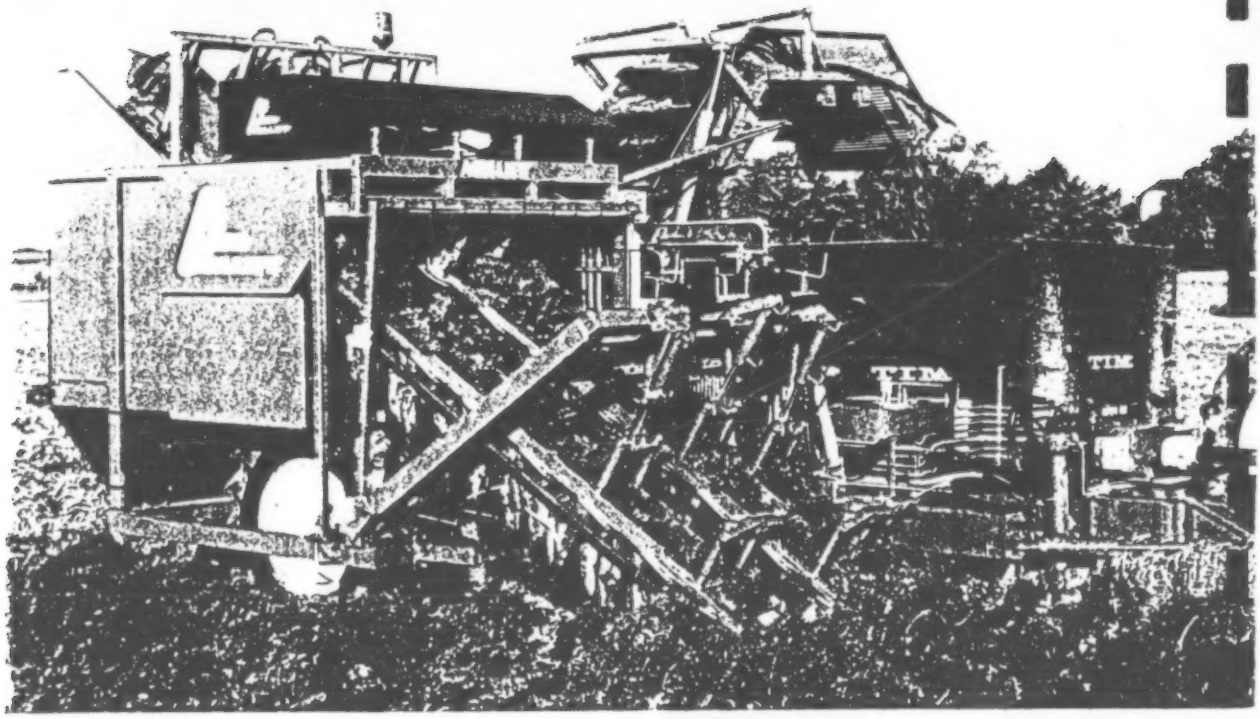
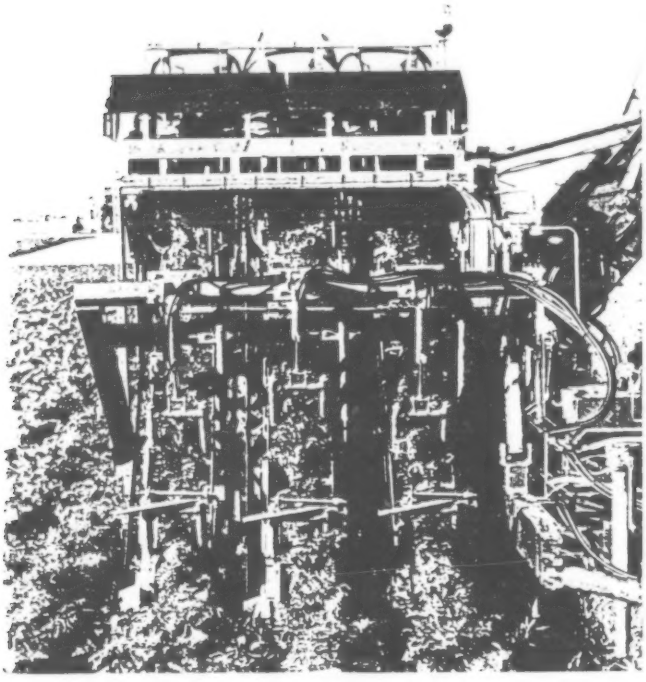
ASA-LIFT





Serie T-100, 200, 30J

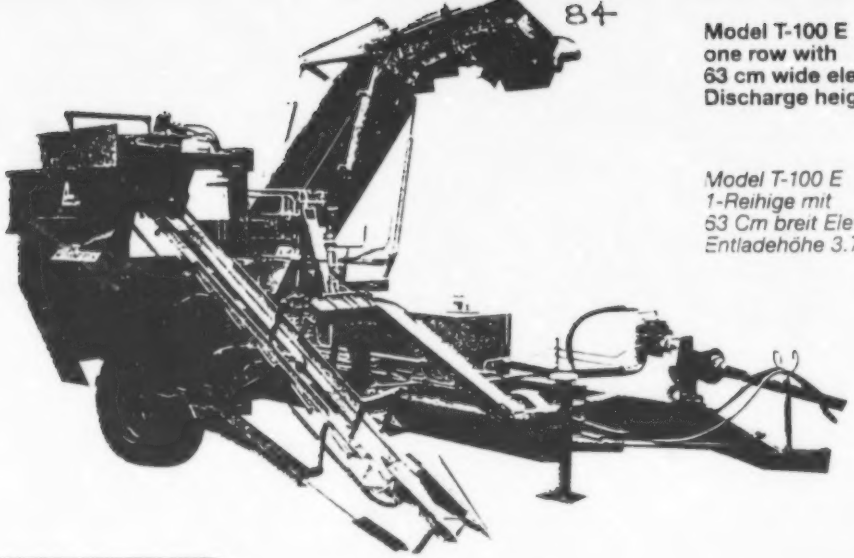
Vegetable Harvesters

Gemüse Vollernter

Recolteuses de Legumes

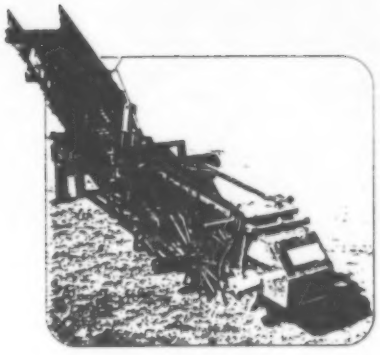
Cosechadoras de Hortalizas

84



Model T-100 E
one row with
63 cm wide elevator.
Discharge height 3.7 m

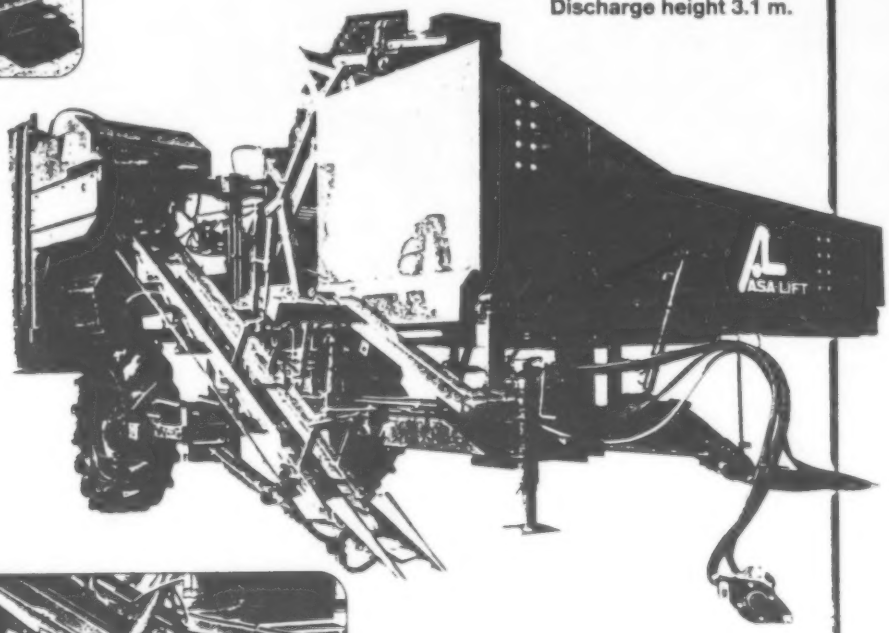
Model T-100 E
1-Reihige mit
63 Cm breit Elevator.
Entladehöhe 3.7 M



Section UT 45 for harvesting topless root crops (when top lifting is impossible)

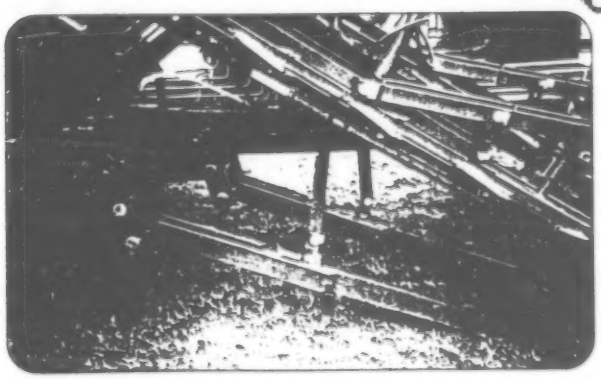
Sektion UT 45 zum Ernte von Gemüse ohne Kraut

Model T-100 B one row with 1.8 tons hopper. Discharge height 3.1 m.



Heavy duty, spring controlled shares with shear bolt protection

Rode Schar, Feder kontrolliert mit Spring Bolz Sicherung



Model T-100 B 1-Reihige mit 1.8 T Bunker

GINSENGER

Ginseng Harvester

- Full width 65" digger bed.
- 0 Clearance to side walls prevents damage to ginseng root.
- 4 sets of heavy duty shakers.
- Depth indicator on digger bed.
- 12" deep digging capability.
- Heavy duty slip clutch on main P.T.O. shaft.
- 6" x 5/8" digger blade.
- 12 - 36mm belted chain.

Vegetable Handling Equipment & Conveyor Systems

WEENING BROTHERS MANUFACTURING INC.

Who says they don't make' em like they used to...

The Ginsenger was designed with the customers needs in mind. High maintenance, bruising, and labor all cost money. This harvester is designed to reduce these costs to a minimum, while still harvesting fast and effectively.

The high quality construction of the ginsenger begins with its heavy duty frame construction, built to withstand even the toughest soil conditions. The 3 or 4 point shakers are very effective in removing all dirt, thus leaving the root easily accessible for picking. Additional shakers can be added at any time in just minutes.

Crop damage and loss are big concerns for all growers. The ginsenger reduces these both to a minimum with its 0 belt clearance to side walls.

The optional side discharge conveyor is designed to save on labor costs, as well as time, making it a very worth while option, especially for larger growers.

Specifications:

Length (ft)	18' 6"
Width (ft)	8' 6"
Digging Depth (in)	12"
HP Requirements	55
P.T.O. Speed	540 RPM
Tires (2)	12.5L - 15
Belted Chain	12 - 36mm

Options:

- Lump Rollers
- Hook Chain
- 2 belt system
- Variety of Belted Chain sizes
- Extra sets of shakers
- Hydraulic shakers
- Side discharge conveyor (24" X 12') c/w - hydraulic drive

Note: Specifications are subject to change without notice

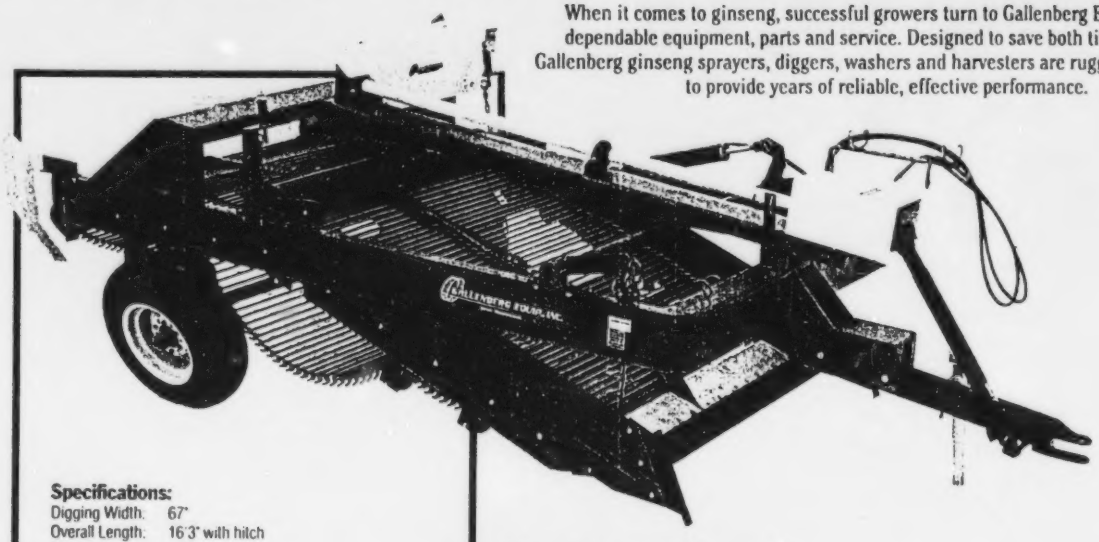
Available From:

WEENING BROTHERS MANUFACTURING INC.

RR # 1 585 Wist Rd
Kettleby, ON L0G 1J0
Tel: (905) 775-3839
Fax: (905 775-8769

When You Think Ginseng, Think Gallenberg

When it comes to ginseng, successful growers turn to Gallenberg Equipment for dependable equipment, parts and service. Designed to save both time and labor, Gallenberg ginseng sprayers, diggers, washers and harvesters are ruggedly constructed to provide years of reliable, effective performance.



Specifications:

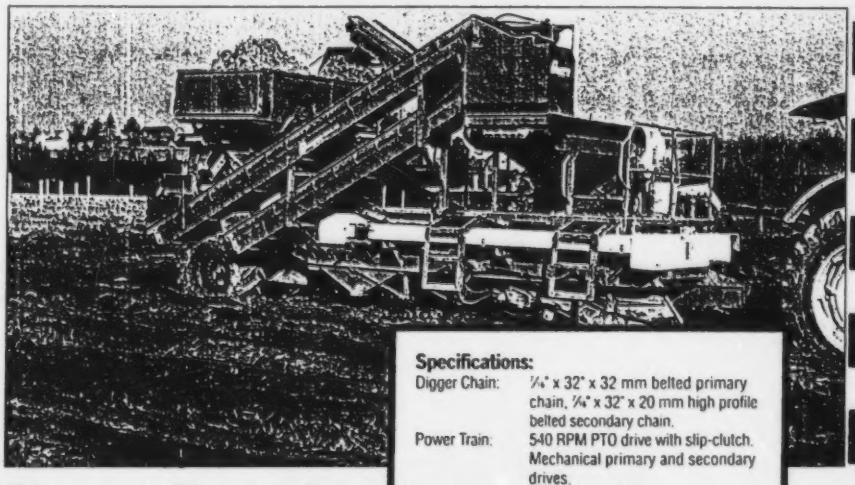
Digging Width:	67"
Overall Length:	16'3" with hitch
Overall Width:	7'9"
Overall Height:	5'
Weight:	Approximately 3,700 pounds (base model)
Digger Blade:	½" x 6" x 67" heat treated steel (bolt-on)
Digger Chain:	⅝" x 32" x 1.56" hook chain tempered steel
Drive Train:	540 RPM PTO drive line with Weasler slip clutch. 90° Durst or equivalent gear drive. 80# tempered steel roller chain and sprockets with Snugulator™ tensioners. 2" diameter primary drive shaft.
Rollers:	Combination of 5" polyurethane and 5" steel rollers. Sealed roller bearing cone rollers.
Tires:	9.5L x 15 SL wheels, 72" on center.

Options:

Digger Chain:	½" x 32" x 1.56" hook chain or ¾" x 32 mm, 36 mm or 40 mm belted chain.
Rollers:	All 5" steel roller bearing rollers. Combination of steel or polyurethane with steel shaker rollers.
Press Roller:	For breaking up dirt clumps (bolt-on).
Roller Shaker:	Variable speed, hydraulic driven shaker on digger section for sifting out heavier soils.
Gathering Pans:	(Bolt-on)
Rock Guard:	Leaf spring (weld and bolt-on).
Boom Assembly:	For rockpicking (bolt-on). Hydraulic drive. Length: Approximately 15' Discharge Height: Approximately 5'. Digger Chain: ⅞" x 21" x 1.56" hook chain with 8 steel flights or ⅞" x 21" x 32 mm belted chain with 8 steel flights.
One Yard Dump Box:	Includes 3 x 12 hydraulic lift and dump cylinders and 8 25-20 tire, tube and wheel on heavy-duty axle. Approximately 48" discharge height.
Windrow Conveyor:	18" x 9' belt conveyor, hydraulic driven, right hand discharge (bolt-on).

Ginseng Digger

This rugged two-bed ginseng digger features an extra heavy formed steel channel frame construction with hydraulic control of digging depth. It can also function as a rockpicker. Depending upon your needs, it is available with or without a self-unloading boom, one-yard dump box or windrow conveyor.

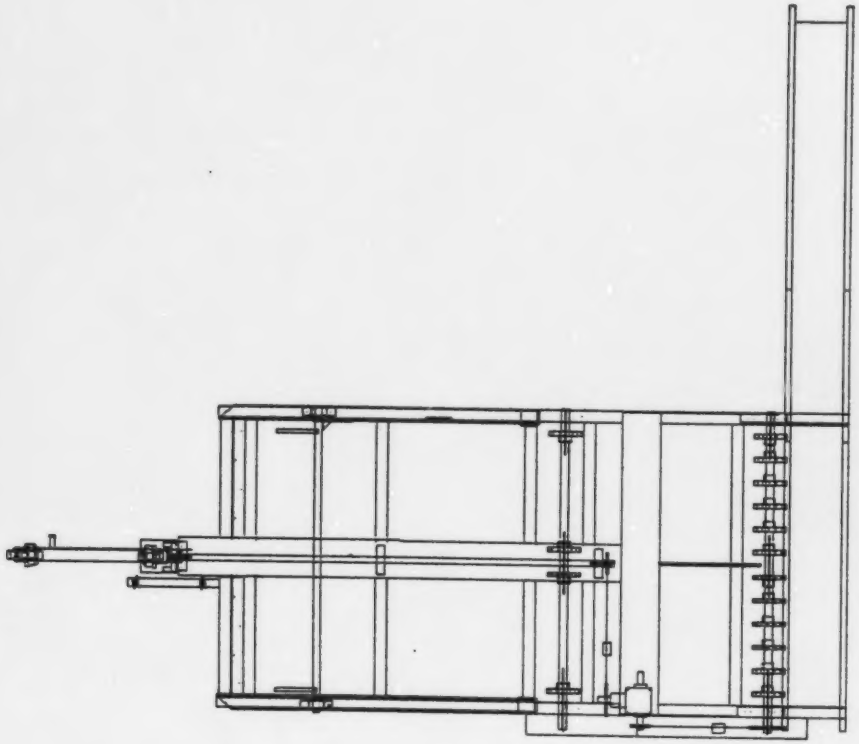


Ginseng Harvester

Patented ginseng harvester is designed for labor saving, one pass harvesting with a high efficiency blower/hedge conveyor combination for particle separation. Trash and root inspection conveyors are included for hand inspection when necessary. The root accumulation bin features automatic unloading into a truck, trailer or wagon. Steerable rear axle, PTO primary drive and independent hydraulic flow controls are featured along with roller shaker to sift heavier soils and 8" diameter press roller to break up dirt clumps.

Specifications:

Digger Chain:	¾" x 32" x 32 mm belted primary chain, ¾" x 32" x 20 mm high profile belted secondary chain.
Power Train:	540 RPM PTO drive with slip-clutch. Mechanical primary and secondary drives.
Hydraulic Controls:	PTO driven hydraulic pump, conveyors and elevators with variable speeds. 40 gallon hydraulic oil reservoir.
Blower:	High efficiency with adjustable fan speed and angle. Input and discharge opening guard grills. Powered by V-belt from 23 HP gasoline engine with 6 gallon fuel tank.
Conveyors:	Full width hedge conveyor, trash and root inspection conveyors.
Bin:	Root accumulation bin has conveyor in bottom, side shift for easy unloading and automatic gate/chute.
Roller:	Spring loaded roller on secondary drive at point of primary discharge.
Roller Shaker:	Hydraulic rotary shaker on primary digger section.
Press Rollers:	8" diameter
Tires:	13.6-16.1 all weather tractor tire, tube and wheel with 72" tire center.
Spindles:	5,790 pound capacity at 20 mph.
Length:	22'
Width:	9'. (L, W & H are approximate)
Height:	11'
Weight:	Approximately 10,000 pounds.



PLANTATION MEDICINAL, INC.

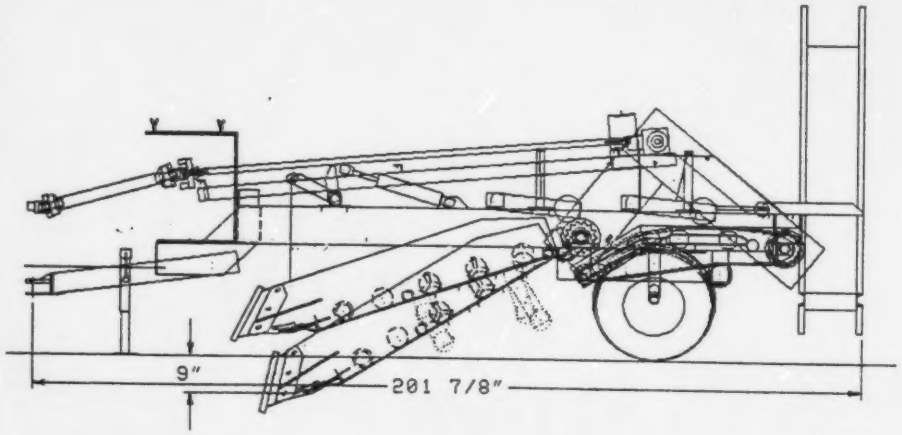
PURPLE CONE FLOWER ROOT HARVESTER

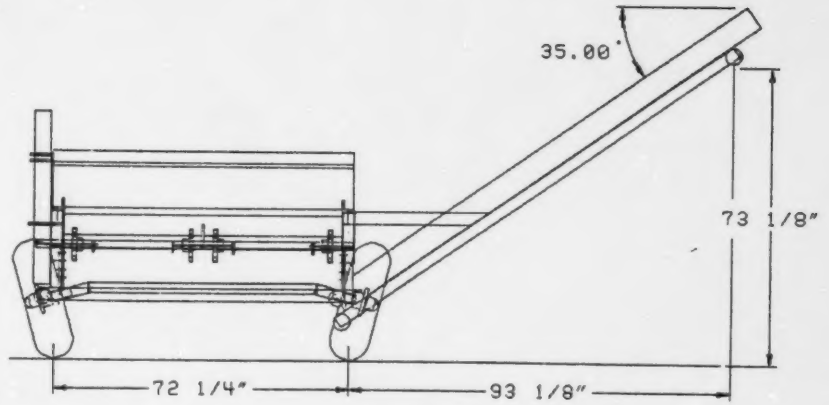
540 RPM PTO DRIVE
7/16" X 32" X 32MM PRIMARY BELTED CHAINS (0.8223" GAP)
TWO ROWS OF SHAKERS (CAN BE REPLACED BY ROLLERS)
1/2" X 1" SECONDARY FERTILIZER CHAIN
TWO ROWS OF SHAKERS
TWO PRESS ROLLERS
12" X 6'-2" BACK BELT CONVEYOR (HYD DRIVE)
12" X 9'-10" BELT ELEVATOR W/ 1" FLIGHTS (HYD DRIVE)
FOUR HYD HOSES TO HOOK UP TO TRACTOR

NEED TO VARY GROUND SPEED AND CHAIN SPEED
FOR OPTIMUM RESULTS

DETAILS ARE APPROXIMATE

E:\DW\JOHN\GINSENG\PLNTMD 7-13-98





Appendix G

Observations and Results from Manual Digs

Date: Oct 19/99

Time: 1:55 pm

Field: Blue Hills Herb Farm
Clay, 3 year, Transplants

Replicate: 1

Plant Spacing: 3" but 8" one way to the next plant and 6" the other way to the next plant

Row Spacing: 51"

Other Observations and Notes

The top 2" is damp. Probably had rain the last day or two.

At the 3 1/2" to 7" level estimated that 90% of the roots in the centre 10".

At the 7" to 10 1/2" level estimated that 90% of the roots in the centre 10".

At the 10 1/2" to 14" same as above level.

At the 14" to 17 1/2" level most of the roots are concentrated near the centre as in the above level however some roots found at the corners as well. This layer was hard to cut at the bottom.

At 17 1/2" to 21 level estimated that 90% of roots in the centre 10".

Roots below 21".

A general observation was that the roots tended to stay in a 10" centre area except at the 14" to 17 1/2" level where they were found across the level.

At 29" below the surface, roots 5/16" in diameter were found. The roots were continuing to go down.

Date: Oct 19/99 and Oct 20/99

Time: 4:15 pm and 8:15 am

Field: Blue Hills Herb Farm
Clay, 3 year, Transplants

Replicate: 2

Plant Spacing: 4" but 8" one direction to the next plant

Row Spacing: 49"

Other Observations and Notes

The soil seemed more damp compared to Replicate 1.

At the 0" to 3 1/2" level roots were concentrated in the centre 12" however white hair roots across the frame.

At the 3 1/2" to 7" level roots were concentrated in the centre 10" however small white roots spread throughout.

At the 7" to 10 1/2" level root distribution same as the above frame.

The depth was checked. It was expected down 10 1/2" but actually down 9 1/2".

For Replicate 1 it was possible to place the wood frame in place and cut under it. This was done on the top four frames. Space limitations did not permit this for frame five and frame six. For this replicate, e.g. Replicate 2, it was not possible to run the knife under the wood frame and cut a slice. The knife was probably dull. For this replicate, e.g. Replicate 2, the wood frame was used to mark 3 1/2", the frame was removed and the slice of soil and roots was shaved off with the knife.

At the 10 1/2" to 14" level the root distribution was similar to the above frame.

At the 14" to 17 1/2" level the roots were generally heading down. Few white thin roots were observed outside 12" on each side.

At the 17 1/2" to 21" level the roots were concentrated at the centre with the odd small lateral.

No observations were made below 21".

Date: Oct 20/99

Time: 2:00 pm

Field: Blue Hills Herb Farm
Sandy, 3 year, Transplants

Replicate: 1, Location top of a knoll.

Plant Spacing: 6" but the plants were staggered back and forth down the row to form a double row. The double row spacing was 4".
(four rows were staggered like this row and eight rows were straight single rows)

Row Spacing: 40" on one side and 60" on the other side

Other Observations and Notes

The top 4" to 5" were a bit sandy but then fairly hard going but not as hard as the clay field. At the 17" level ran into a whitish soil that looked like lime. The field had the odd small stone. The top had a little moisture but mostly dry.

At the 0" to 3 1/2" level two main stems, no laterals and few white hair roots.

At the 3 1/2" to 7" level few lateral roots.

At the 7" level the soil changes from sandy to a harder clay. The soil has a red hue to it.

At the 7" to 10 1/2" level few laterals, most of the root is concentrated at the core where the centre tap root goes down.

At the 10 1/2" to 14" level more lateral roots that go right to the edge of the section.

At the 14" to 17 1/2" level into whitish soil. Few lateral roots and much smaller.

At the 17 1/2" to 21" level the roots were generally small and not many laterals.

Date: Oct 20/99 and Oct 21/99

Time: 4:45 pm and 8:30 am

Field: Blue Hills Herb Farm
Sandy, 3 year, Transplants

Replicate: 2, Location toward bottom of a knoll.

Plant Spacing: 5" but variable 6", 4" and spaces

Row Spacing: 48"

Other Observations and Notes

The top 12" seem easy to dig, sandy and looks dry.

At the 0" to 3 1/2" level white hair roots across the section. No large laterals.

At the 3 1/2" to 7" level white hair roots and laterals across the section.

At the 7 to 10 1/2" level laterals across the section but all small diameter.

At the 10 1/2" to 14" level small diameter roots and most concentrated in the core area.

At the 14" to 17 1/2" level roots just in the core which is 10" in diameter.

At the 17 1/2" to 21" level roots just in the core which is 10" in diameter.

The stems in the sandy, 3 year, replicate 1 and 2 were 1/4" diameter or so while the stems in the clay, 3 year, replicate 1 and 2 were nearly 1/2".

Date: Oct 21/99

Time: 10:30 am

Field: Blue Hills Herb Farm
Sandy, 2 year, Transplants

Replicate: 1, Location was the side of a knoll near the bottom of the field.

Plant Spacing: 6" but in area dug 3" to 4"

Row Spacing: 66"

Other Observations and Notes

The top 14" is quite sandy and then clay. It was estimated that there was 7" of top soil.

At the 0" to 3 1/2" level lots of fine white hair roots.

At the 3 1/2" to 7" level the roots are small and few laterals.

At the 7" to 10 1/2" level really just the main tap root.

At the 10 1/2" to 14" level very small roots.

The soil was difficult to rub off the roots.

Date: Oct 21/99

Time: 2:15 pm

Field: Blue Hills Herb Farm
Sandy, 2 year, Transplants

Replicate: 2

Plant Spacing: 4" but 6" in other neighbouring rows

Row Spacing: 60" but variable 56" to 64"

Other Observations and Notes

The farmer commented that the 2 year old plants were planted and then faced a 10 week drought. The plants seemed to have died but came back.

The outside most westerly seven or eight rows were very patchy and stunted so did not use any of them.

At the 3 1/2" to 7" level lots of fine white hair roots. The roots were small.

Date: Oct 21/99

Time: 3:30 pm

Field: Blue Hills Herb Farm
Sandy, 2 year, Direct Seeded

Replicate: 1, Location was the top of the field. It was the highest point in the field.

Plant Spacing: 2" but very erratic, 16 plants in 12"

Row Spacing: 62" on one side and 70" on the other side

Other Observations and Notes

The top soil was 3" thick. Below the top soil it was sandy.

At the 3 1/2" to 7" level more laterals than the above level.

At the 7" to 10 1/2" level no laterals. All the roots were in the core.

Date: Oct 21/99

Time: 5:00 pm

Field: Blue Hills Herb Farm
Sandy, 2 year, Direct Seeded

Replicate: 2

Plant Spacing: 17 plants in 12"

Row Spacing: 67" on one side and 72" on the other side

Other Observations and Notes

The top soil was 3" thick. Below the top soil it was very sandy.

Date: Nov 04/99

Time: 2:20 pm

Field: Farm of Wendy James and Ron Gillies
3 year, Transplants

Replicate: 1

Plant Spacing: double row: 6" spacing along the row and 6" between the rows (reported by the farmer)

Path Width: 26" (reported by the farmer)

Other Observations and Notes

General Observations

Mr. Ron Gillies had removed all the tops from the plants prior to our arrival at the field and most of the harvesting was complete. A single row was left to be harvested. Two locations in this row were used for the manual diggings.

Mr. Gillies mentioned that he had put 5" to 6" of water on the field. The amount was based on how much the dug-out was lowered and the fact that the two areas were about the same size. When harvesting started the field was very dry and the soil broke into large clods that made retrieval of the roots difficult. The water was added so the soil would crumble during harvest. The soil was very wet on top.

I spoke to Ron Makahonuk in the evening and he offered the following additional comments. He said that he estimated the top soil to be 8" to 12" thick. He said it was thicker than at Blue Hills Herb Farm. Beneath the top soil it was pure sand. He thought not as many laterals as at Blue Hills Herb Farm.

Observations for this Digging

Two plants were inside the digging area and two plants were at the perimeter of the digging area. The two plants at the perimeter were approximately 12" from the nearest plant inside the digging area. The main stems from the perimeter of the digging area were not included in the sample.

Date: Nov 04/99

Time: 4:00 pm

Field: Farm of Wendy James and Ron Gillies
3 year, Transplants

Replicate: 2

Plant Spacing: double row: 6" spacing along the row and 6" between the rows (reported by the farmer)

Path Width: 26" (reported by the farmer)

Other Observations and Notes

One plant had an extensive top, e.g. approximately 10 stalks, and the crown was 1" in diameter. It was questioned whether this plant was older than 3 years. The other plants had smaller tops, e.g. approximately 3 stalks, and the crown was 1/2" in diameter.

At the 0" to 3 1/2" level no significant lateral roots.

The soil was extremely moist to the bottom of the digging.

Date: Nov 24/99
Time: 10:50 am
Sample Description: Blue Hills Herb Farm
Clay, 3 year, Transplants, Replicate 1

Details of Crown Trim

Almost no top removal. Three stems and one of them may have had too much cut off in the field. The stems were: two at 6" long and one at 4 1/2" long (I expected them to be 3 1/2" or so.).

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	100.80	Only 2 laterals.	37.28	36.6	36.6
2	67.74	Lots of small diameter roots.	25.94	25.5	62.1
3	36.01	Lots of very small diameter roots.	13.77	13.5	75.6
4	17.91	Few roots.	6.95	6.8	82.4
5	26.83	Many small diameter roots.	10.30	10.1	92.5
6	20.48	Tiny roots.	7.54	7.4	99.9
Total	269.77		101.78		

Date: Nov 23/99
Time: 9:05 am
Sample Description: Blue Hills Herb Farm
Clay, 3 year, Transplants, Replicate 2

Details of Crown Trim

Cut 1 1/2". One large stem and three small stems.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	44.52	Few laterals.	17.01	20.2	20.2
2	55.52	Few laterals.	20.98	24.9	45.1
3	41.90		16.25	19.3	64.4
4	34.39		13.80	16.4	80.8
5	23.69		9.25	11.0	91.8
6	19.07		6.86	8.2	100.0
Total	219.09		84.15		

Date: Nov 24/99
Time: 9:05 am
Sample Description: Blue Hills Herb Farm
Sandy, 3 year, Transplants, Replicate 1

Details of Crown Trim

Four stems. Removed 1" from each top.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	45.09	No laterals. Just four main stems with tiny little white hair roots.	18.47	12.8	12.8
2	81.91	Lots of laterals.	34.09	23.6	36.4
3	79.72	Lots of laterals.	32.84	22.7	59.1
4	77.99	Lots of laterals.	32.60	22.5	81.6
5	40.92	Fewer roots.	17.08	11.8	93.4
6	26.08	Just small roots.	9.65	6.7	100.1
Total	351.71		144.73		

Date: Nov 23/99
Time: 10:40 am
Sample Description: Blue Hills Herb Farm
Sandy, 3 year, Transplants, Replicate 2

Details of Crown Trim

Trimmed 1 1/2" to 1 3/4". Three large stems.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	64.23		23.16	20.6	20.6
2	93.24	Lots of laterals.	35.54	31.7	52.3
3	40.20	Lots of small/fine roots.	15.14	13.5	65.8
4	36.29	Lots of small/fine roots.	13.74	12.2	78.0
5	37.76	Lots of small/fine roots.	14.04	12.5	90.5
6	25.92	Lots of small/fine roots.	10.57	9.4	99.9
Total	297.64		112.19		

The tops were dried and gave a mass of 9.95 grams.

Date: Nov 25/99
Time: 9:15 am
Sample Description: Blue Hills Herb Farm
Sandy, 2 year, Transplants, Replicate 1

Details of Crown Trim

Three stems. Removed 1/4" on two of them.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	37.75	Three main stems dominant.	13.49	51.0	51.0
2	15.47	Small diameter and short length roots.	5.67	21.4	72.4
3	13.10	Laterals all small diameter.	4.89	18.5	90.9
4	6.59	Few laterals, just small diameter stems.	2.42	9.1	100.0
Total	72.91		26.47		

Date: Nov 24/99 and Nov 25/99
Time: 12:00 noon
Sample Description: Blue Hills Herb Farm
Sandy, 2 year, Transplants, Replicate 2

Details of Crown Trim

Three stems. Trimmed 1/2" to 3/4" off.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	33.10	A few small diameter laterals.	11.54	29.5	29.5
2	38.68	Lots of small diameter long laterals.	13.64	34.9	64.4
3	28.28	Lots of small diameter roots.	9.68	24.8	89.2
4	12.37	Few and small roots.	4.23	10.8	100.0
Total	112.43		39.09		

Date: Nov 25/99
Time: 10:30 am
Sample Description: Blue Hills Herb Farm
Sandy, 2 year, Direct Seeded, Replicate 1

Details of Crown Trim

Seventeen tops. Removed 1/2" to 3/4" on all but two.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	67.12	Stems have laterals.	23.85	38.9	38.9
2	53.05	Lots of small roots.	19.65	32.0	70.9
3	25.88	Lots of small roots, few laterals.	9.52	15.5	86.4
4	21.13	Lots of small diameter roots, few laterals.	8.30	13.5	99.9
Total	167.18		61.32		

Date: Nov 25/99 and Nov 29/99
Time: 11:35 am
Sample Description: Blue Hills Herb Farm
Sandy, 2 year, Direct Seeded, Replicate 2

Details of Crown Trim

Nineteen tops. Most removed 1 3/4" to 2 1/4". Six stems removed 1" to 1 1/4".

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	45.01	Mostly stems. Very few laterals.	16.05	22.2	22.2
2	119.89	Lots of small diameter roots.	41.12	56.9	79.1
3	26.10	Very small diameter roots.	9.51	13.2	92.3
4	15.28	Very small diameter roots.	5.58	7.7	100.0
Total	206.28		72.26		

In Frame 2 not all the roots were nice and smooth. Some of the roots had nodules or bumps.

The tops were dried and gave a mass of 10.65 grams.

Date: Nov 29/99 and Dec 7/99
Time: 10:00 am
Sample Description: Farm of Wendy James and Ron Gillies
3 year, Transplants, Replicate 1

Details of Crown Trim

Tops removed below the crown. Nothing was removed in the lab. Two stems. One stem 5/8" to 3/4" diameter and the other 1/2" diameter.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	39.00	Almost all weight in two stems.	13.15	18.6	18.6
2	39.49	Few laterals.	14.62	20.7	39.3
3	33.08	Few laterals.	12.35	17.5	56.8
4	28.20	Few laterals.	10.25	14.5	71.3
5	39.62	More laterals than previous two frames.	14.54	20.6	91.9
6	16.06	Few laterals.	5.72	8.1	100.0
Total	195.45		70.63		

Date: Dec 7/99
Time: 10:30 am
Sample Description: Farm of Wendy James and Ron Gillies
3 year, Transplants, Replicate 2

Details of Crown Trim

Crowns probably over trimmed. Four stems in total. One stem 7/8" diameter. The remaining stems were 1/2" to 3/8" diameter.

Frame	Wet Weight (grams)	Observations	Dry Weight (grams)	Dry Wt / Dry Wt Ttl (%)	Sum (%)
1	55.57	No laterals, just four stems.	18.71	18.3	18.3
2	63.38	The one main stem dominant. Lots of small roots.	21.53	21.1	39.4
3	61.36	Lots of small roots and laterals.	21.25	20.8	60.2
4	45.28	Lots of small roots.	16.08	15.7	75.9
5	49.08	Range of roots sizes, small to 5/16" diameter.	18.00	17.6	93.5
6	18.16	Three fairly sizeable roots 5/16" diameter and a few small roots.	6.64	6.5	100.0
Total	292.83		102.21		

Appendix H

Observations and Results from Mechanical Harvesting Trials

Date: Oct 28/99
Time: 11:30 am
Location: Blue Hills Herb Farm
Plant Age: 3 year, Transplants
Soil Type: Clay
Soil Moisture: Dry

Tractor
Make: Massey Ferguson
Model: 2705
Engine HP:
Tire Size & Condition:

Harvester Type: Ginsenger

Plant Topping Observations

The Ginsenger went over two rows. The two rows had been previously dug with a single row carrot harvester. Removal of the tops was not a consideration.

Harvesting
Tractor Speed: 2000 rpm and lowest gear
PTO RPM: 540 rpm based on engine speed

Engineering Harvesting Observations

The Ginsenger was set to harvest 9" deep. The manual diggings after harvesting replicate 1 and replicate 2 indicated no evidence of the carrot harvester. The manual diggings after harvesting replicate 3 indicated the carrot harvester was down 9" in two rows. Gary and Jim (farmers) thought the carrot harvester was digging 14" deep. An examination of the carrot harvester indicated that the hitch, the shovel arm and the ram form a triangle. The ram probably had a 20" extension. With the digging shovel on the soil surface, the ram needed to be partly extended for the harvester to be hitched. The triangle between the hitch, the shovel arm and ram indicates that a change in the ram extension does not provide an equal increase in digging depth.

Farmer Harvesting Observations

None provided by the farmers.

Harvesting Depth
Replicate 1: 7" on one side and 9" on the other side
Replicate 2: 8" on one side and 9" on the other side
Replicate 3: 5" on one side and 7" on the other side
The manual digging width was 13" for replicate 1.

Date: Oct 28/99
Time: 2:00 pm
Location: Blue Hills Herb Farm
Plant Age: 3 year, Transplants
Soil Type: Clay
Soil Moisture: Dry

Tractor
Make: John Deere
Model: 3130
Engine HP:
Tire Size & Condition:

Harvester Type: Bartschi FOBRO Super HD Lifter/Shaker

Plant Topping Observations

A small strip had been missed by the carrot harvester. It was assumed that the tops were cut a few inches above the soil surface with a swather. The roots were trimmed with a pruning shears after digging to complete the top removal.

Harvesting
Tractor Speed:
PTO RPM:

Engineering Harvesting Observations

The Bartschi FOBRO was harvesting only a single row. A second row was about 6" outside the width dug by the Bartschi FOBRO.

The third link of the three-point hitch should have been closed further so the tines at the rear of the harvester lifted further out of the ground. The link was probably lengthened to avoid banging while the harvester went through the clay.

Farmer Harvesting Observations

None provided by the farmers.

Harvesting Depth
Replicate 1: 8" but hard to measure
Replicate 2: 9 1/2"
Replicate 3: 8"
The manual digging width for replicate 1 and 2 was 12".

Date: Oct 28/99
Time: 3:30 pm
Location: Blue Hills Herb Farm
Plant Age: 2 year, Transplants, west side row five from east side
Soil Type: Sandy
Soil Moisture: Dry

Tractor
Make: Massey Ferguson
Model: 2705
Engine HP:
Tire Size & Condition:

Harvester Type: Ginsenger

Plant Topping Observations

A swather had passed over the plants prior to harvest and left about 3" to 4" stalks.

Harvesting
Tractor Speed: assumed same as clay field, 2000 rpm and lowest gear
PTO RPM: assumed same as clay field, 540 rpm

Engineering Harvesting Observations

A single row was harvested.

The plants were easy to locate and they came out with nearly intact root systems. Soil clods were not a problem. The tractor operator was trying to dig 12" deep and every 10' or so he would have to lift the harvester because the tractor would loose traction. The manual diggings after harvesting indicated the soil profile had not been significantly disturbed by the harvesting.

Farmer Harvesting Observations

The tractor operator said the tractor was working hard. He said the tractor was not working hard in the clay. The difference was probably due to the difference in digging depth.

Harvesting Depth
Replicate 1: 14"
Replicate 2: did not measure but seemed same as above
Replicate 3: 10"

General Observations Nov 01/99

The harvesting method followed by Blue Hills Herb Farm involved removing most of the tops using a swather and digging the roots with an FMC carrot harvester. The FMC harvester left some roots in the soil. A second digging was completed using the Ginsenger.

The FMC harvester removed the plant tops. Topping bars pinched the tops off at the crown. The topping bars were sharpened and adjusted during the harvest. The farmers reported that by the end of the harvest the topping bars worked satisfactorily. Observations of roots in the drying boxes indicated that the crowns were not clean-cut but frayed. It was also observed that the root systems were not intact but mainly the main tap root.

The farmers mentioned that in the 3 year plants in the clay field that some of the stems were thick like a persons thumb. These thick stems would stop the harvester as if a rock had jammed in the cutting blades.

Jim (one of the farmers) estimated that 15% of the roots were harvested with the Ginsenger.

The farmers said the Bartschi FOBRO only received three to four hours of use.

It is recommended that investigations be undertaken with a topping mechanism. If the tops can be removed then the Ginsenger or the Bartschi FOBRO will work in sandy soil. In clay soil the clods on top make harvest difficult for the Bartschi FOBRO or the Ginsenger. In clay the Ginsenger probably has the best chances. Rollers could be used to break the clods. A slower chain speed with aggressive hydraulic agitation may also break the clods.

The Bartschi FOBRO was loaded on the trailer before it could be operated in the second year sandy plants.

Farmer Comments Dec 20/99

The motivation for Blue Hills Herb Farm to use the FMC carrot harvester was that it provided digging, topping and loading all in one machine. They liked the narrow digging width of the FMC harvester. The digging blade was L shaped. This was an advantage because trash would not catch on the arm supporting the digging blade. The digging blade was thin and not very wide. The digging depth control and the steering capacity were also positive features of the FMC harvester. Under some conditions the lifting belts worked well. The farmers would replace the lifting belts with a chain similar to the Ginsenger. The optimum harvesting width would be 12" to 18". Travel speed was important with the FMC harvester: slow speeds dirt piled-up and fast speeds the plants piled-up. The topping bars either jammed with a large root or weed or did not provide a clean cut. The farmers are considering to use a mower or another topping machine ahead of the FMC harvester.

The soil in the field was not prepared before the FMC harvester was used.

The FMC harvester did miss laterals that the Ginsenger collected.

The farmers harvested 64,000 plants and they collected 1400 lbs of dry root. They harvested about 40 plants per lb. Other farmers were as high as 60 plants per lb. They expected to harvest 3000 to 4000 lb of dry root based on their rate of harvesting last year.

The problem with the Ginsenger is that it is too wide. The Ginsenger turns over lots of soil and requires lots of tractor power. The FMC harvester requires little tractor power. An advantage of the Ginsenger is that it can have a box at the back to collect roots.

The farmers thought that picking-up the crop was an important limitation of the Bartschi FOBRO. They also noted that the digging action of the Bartschi FOBRO was hard on the tractor. The farmers thought that the Bartschi FOBRO was well built and that the spaced digging fingers were good. It seemed that carrot pins ahead of the digging blade was a good idea.

The farmers were reluctant to consider a 24" row spacing because this row spacing does not fit their existing field equipment. The farmers were very committed to a single row harvester.

Date: Dec 8/99
Time: 9:45 am
Sample Description: Blue Hills Herb Farm
Clay, 3 year, Transplants
Ginsenger

Replicate	Wet Weight (grams)	Observations	Dry Weight (grams)
1	48.65	Largest diameter fragment 7/16". Longest fragment 5". Most fragments 3" long.	18.06
2	44.26	Largest diameter fragment 3/8". Longest fragment 6". Most fragments 3" long. Wide range of root diameters.	17.56
3	14.76	Largest diameter fragment 1/4". Longest fragment 4". Most fragments 3" long. Small number of roots.	5.69

Date: Dec 7/99 and Dec 8/99
Time: 11:35 am
Sample Description: Blue Hills Herb Farm
Clay, 3 year, Transplants
Bartschi FOBRO

Replicate	Wet Weight (grams)	Observations	Dry Weight (grams)
1	36.22	Largest diameter fragment 1/4". Fragments up to 9" long.	13.43
2	55.42	Largest diameter fragment 1/4". Fragments up to 7" long. Most fragments small diameter.	22.60
3	31.24	One fragment 3/8" diameter. Most fragments smaller and about 3" long.	12.39

Date: Dec 8/99
Time: 10:20 am
Sample Description: Blue Hills Herb Farm
Sandy, 2 year, Transplants
Ginsenger

Replicate	Wet Weight (grams)	Observations	Dry Weight (grams)
1	11.45	Largest diameter fragment 3/16". Longest thin lateral 9" long. Range of lengths 1 1/2" to 9".	4.00
2	1.45	Only small white roots.	0.44
3	3.28	Only small diameter roots. Mostly in one lateral 27" long.	1.02

Appendix I

'Looking for Root Digging Equipment?'

Looking for Root Digging Equipment?

By VICTOR TAYLOR

One of the more important tasks in growing root crops such as Echinacea is harvesting. And many growers have been contacting the SHSA to find out what equipment is available. The University of Saskatchewan as represented by Assistant Professor Trevor Crowe of the Agriculture & Bioresource Engineering department, was successful in obtaining funds from Agriculture Diversification Fund, to investigate the existence and adaptability of equipment that could be applied to digging herb roots in Saskatchewan. The University assigned the fact gathering phase of the project to Myles Bantle of Bantle Engineering Research in Saskatoon.

I, as a representative of Blue Hills Herb Farm Inc., was honored to be asked, to participate in the research project. Hopefully, through this article and a presentation planned for the conference in January, growers will have a better idea of the potential answers to the harvesting question.

Myles did a great deal of literature searching and telephoning numerous machinery manufacturers in search of applicable machinery. A quick tour of potential sites to see equipment at work was developed. The equipment selected for further investigation, include items commonly used in the Ginseng, nursery and the vegetable row crop industries. We visited sites in Oregon, Washington, Ontario and Wisconsin. The sites visited included both government and business operations.

The first observation from a Saskatchewan herb growers perspective was that most industries that have equipment adaptable to harvesting herbs are used in much larger scale operations compared to the average acreage of herbs grown in Saskatchewan. This observation leads to a concern about the scale of capitalization affordable to small scale growers. Equipment used to harvest 400 acres of carrots or 1200 acres of onions is generally too expensive for plots of only a few acres.

The second observation is that other industries have had a long time to perfect a system of equipment based on standardized row crop land management techniques. Where we tend to use what field and garden equipment is laying around the farm yard for planting, cultivating and harvesting; row crops are grown in rows laid out by transit and laser beams, tractor tires are set at a standard width and all the equipment is set to work consistently over set row densities. In talking to many producers over the last few years I know that there is quite a variation of how we as a group plant our plots and fields. Row width varies from the density of 48" raised beds to double rows 18 inches apart to single rows three feet apart. To make the best use the row crop equipment for harvesting we would need to plant rows in a fashion that makes the best use of the harvester. That may mean also having to set your tractor tires differently than its other uses on the farm, or dedicating a tractor to the herb crops. It may also require you to buy cultivating equipment that can be used for the row density you have selected.

The root digging equipment we saw on the trip were variations on the U plow. A typical unit may have a blade, 30 to 60 inches wide, that is adjustable for depth, and has some form of shaker mechanism to knock dirt off the crop. The more costly units also convey the root up a set of chains to a container at the side or back of the digger. The cost for this equipment ranges from $4,000.00 CDN for a 30" wide digger to $5,000.00 to $8,000.00 U.S. used for 60" wide diggers all the way up to $60,000.00 US for a new 60" row digger.

The chain that conveys the root comes in two basic styles: Hook Chain and Belted Chain. The belted is the newer version and tends to last longer than the hooked chain. The chain is also variable in thickness and space between the them. Echinacea root requires a smaller distance (approximately 32 mm.) between the links than most vegetable crops.

The equipment we saw was used on such crops as potatoes, horseradish, carrots, Ginseng, small trees, and *Echinacea Purpurea*. The soil these crops were grown in varied from peat to very light powdery soil. All the fields were irrigated. The depth of cutting was down to about 12 to 14 inches. The tractors required to run the hydraulics and to reach the desired depth had a horsepower range of 50 to 80 HP, and preferably 4WD. A grower could easily harvest two acres a day with the right tractor and soil conditions.

These diggers do not top the plants. Growers would have to decide how to top and when to top the plants in the harvesting process. Topping before digging is the preferred method since the trash does not interfere with the rest of the process. There are several choices for the topping stage. Row crop flailers using metal or plastic flails are commonly used. A more precise instrument called a crowner could follow the flail. The crowner is used in the carrot trade to cut the tops slightly below the surface. To cut the tops after digging is a very labour intensive exercise.

In summary, there are lots of choices of equipment available but the cost in most cases will make the choice for us. Groups of growers formed to share the costs of purchasing equipment may be a realistic alternative worthy of consideration. Another alternative may be for someone to buy the equipment and then rent it to individual growers.

For those readers wishing to get more detailed information directly from the manufacturers, you may wish to contact them at the following addresses.

Weening Brothers Manufacturing Inc., Wist Road, R.R.#1 Kettleby, Ontario, L0G 1J0, Phone (905) 775-3839, Fax (905) 775-8769. Single and Double Row Ginseng diggers

Gallenburg Equipment Inc., W9112 Cherry Rd., Antigo, Wisconsin, 54409, Phone (715) 623-3754, Fax (715) 627-4557; New and Used Ginseng equipment.

KPR Inc., P.O. Box 608, 375 West Ave., "D", Wendall, Idaho, 83355 - 0608, Phone (208) 536-6601, Fax (208) 536-6695; Full range of new and used row crop equipment.

Bartschi-Fobro AG, Dorfl/ PostFach 1/ CH-6152 Huswil/Schweiz, Phone 41 (0) 41 988 21 21, Fax 41 (0) 41 988 22 86. Nursery equipment.

Lost or misplaced your application to our January conference .....contact Cathy for another. Your input is vital to this industry and your attendance at this conference may make a difference in your own operation. See you there!

Saskatchewan Herb and Spice Association, Herb and Spice Day - January 14, 2000

ANNUAL GENERAL MEETING

8:00 a.m. Coffee and Registration for both AGM and Conference (registration desk open till 10am)

8:15 a.m. Welcome, introduce Directors, approve agenda , Minutes of 1999 Annual Meeting. 1999 Financial Report, President's and Directors Reports Amendments to Bylaws (if any), Election of Directors , Any Other Business

9:45 a.m. Coffee

CONFERENCE

The Herb and Spice Marketplace in the New Millennium

10:00 a.m. Conference Introduction.

10:15 a.m. **Keynote Speaker - Bill Reynolds** - *LOOK INSIDE NEWSLETTER FOR MORE INFO*

11:00 a.m. **RESEARCH IN PROGRESS** - Concurrent sessions

Minor Use Registration update - Ray McVicar, Saskatchewan Agriculture and Food

Diseases of Herbs and Spices - Penny Pearce, Saskatchewan Agriculture and Food

Herb Research under Irrigation -Dr. Jazeem Wahab, Saskatchewan Irrigation Development Centre

Spice Research at the AFIF Spoke Sites - Rachael Oystryk, East Central Research Foundation, Canora

Spice Breeding - Dr. Al Slinkard, Crop Development Centre, University of Saskatchewan

CONSUMER TRENDS - Kelly Fitzpatrick, President Sask. Nutraceutical Network

12:30 p.m. LUNCH - **HERBS 2000** - Connie Kehler

1:30 p.m. **PRODUCTION AND PROCESSING OF HERBS** - Concurrent sessions

Post-harvest processing of selected herbs - Julie Carrier, Agricultural and Bio resource Engineering, University of Saskatchewan

Commercial Processing Herbs, Spices and Medicinals - Dr. Shahab Sokhansanj Agricultural and Bioresource Engineering, U of S

Research on Herb Quality- Branka Barl, Plant Sciences, University of Saskatchewan

Organic production of Herbs and Spices- Debbie Miller, Saskatchewan Organic Directorate

SUCCESS STORIES OF SASK. ENTREPRENEURS

Roy Sangster - **Sangster's Health Centres**

Brad Grimes - **Nutrivim**

Grant Marcotte - **Paradise Herbs**

THE 3 R'S OF VALUE ADDED PROCESSING - Catherine Folkerson

2:30 p.m. Coffee

3:00 p. m. **SHSA - HERB AND SPICE MARKET STUDY** - Ron Dalgleish

5:00 p.m. Adjourn

Appendix J

'Mechanical Harvesting of Echinacea Roots'

Mechanical Harvesting of Echinacea Roots

Myles Bantle[1], Julie Carrier[2] and Trever Crowe[2]
[1] Bantle Engineering Research, Saskatoon
[2] Department of Agricultural and Bioresource Engineering,
University of Saskatchewan

Commercial harvesters exist for many root crops including, potato, carrot and ginseng. A commercial harvester for Echinacea angustifolia roots does not exist. A project was initiated to select a suitable commercial root harvester, to test the harvester during one harvesting season and to provide recommendations to growers for harvesting E. angustifolia roots. The project is still under way. Visits have been completed to five North American suppliers of root harvesting equipment and two different commercial root harvesters were tested at Blue Hills Herb Farm, Inc., Hearne, SK. The work to date has focussed on existing commercial root harvesting equipment and their suitability for Saskatchewan E. angustifolia growers.

Visits were made by a Saskatchewan Echinacea grower and an engineer to Washington and Oregon and to southern Ontario and Wisconsin. The objectives of the visits were to evaluate various root harvesting equipment, meet with five equipment suppliers and one Echinacea root wholesaler and attend a nursery trade show. Four of the equipment suppliers provided one-day tours of their equipment and three of the four equipment suppliers demonstrated their equipment. The combination of a grower and an engineer provided a comprehensive investigation that could not have been completed by either alone. The visits highlighted production opportunities from mechanization and integrated production methods. The visits also revealed harvesters with a range of features and indicated that adaptation to Saskatchewan soils and E. angustifolia may be necessary.

The farms visited varied in the level of production sophistication. The most sophisticated farm, a farm in Washington, produced 485 hectares (1200 acres) of carrots and 160 hectares (400 acres) of onions. This farm had very integrated and high-capacity production methods. The fields were level, and the crops were grown in carefully groomed and perfectly straight raised beds. The area was dry and irrigation provided most of the crops' water requirements. The carrot tops were precisely removed prior to harvesting using a rotary flail followed by a specialized crowner. The carrots were harvested using a high capacity fully-automatic harvester that loaded the crop into semi-trailers for transport to a processor. The other farms visited were not as sophisticated but all used mechanization and integrated-systems approach to planting, weeding and harvesting. Saskatchewan Echinacea growers would achieve improved productivity through mechanization and more integrated production methods.

Operating root harvesters manufactured by three different companies were observed: AMAC Model G2 harvester, Bartschi FOBRO Super HD Lifter/Shaker and Weening Brothers Manufacturing Ginsenger. All three harvesters were operated in sandy soils. The equipment suppliers recommended loosening the soil prior to harvest. Many other non-operating harvesters were also observed. The AMAC Model G2 was observed harvesting carrot in Washington. The harvester was a high-capacity automatic full-feature harvester. The primary digging tool was a row of carrot pins that could be rotated to adjust the digging depth. The advantage of the carrot pins was that if they caught the subsoil and bent they could be easily replaced. The harvester features permit good soil, stone and trash removal prior to automatic

loading into a truck. A used older AMAC harvester would cost $ 34,000 and was probably too expensive for Saskatchewan Echinacea growers. The Bartschi FOBRO Super HD Lifter/Shaker was operated in a fallow field at a Washington tree nursery. The Bartschi FOBRO Super HD Lifter/Shaker was the smallest harvester and the only harvester which attached to the tractor using a three-point hitch. The primary digging tool was an oscillating under-cutter-blade. The harvester lifted the roots to the soil surface where the roots were manually collected. This harvester was the only one that during the tours was reported by a farmer to be operated in clay soils. The design and construction of the harvester indicated that it may achieve the deepest digging depth of the three harvesters observed operating. A new Bartschi FOBRO Super HD Lifter/Shaker would cost $ 17,000 and was one of the least expensive new harvesters. Unfortunately, the supplier did not sell used-harvesters. The Bartschi FOBRO Super HD Lifter/Shaker appeared to be the best choice for Saskatchewan Echinacea growers. A harvester produced by Weening Brothers Manufacturing, the Ginsenger, was observed harvesting E. purpurea in southern Ontario. The Ginsenger and the Gallenberg Equipment, Ginseng Digger, were very similar harvesters. Both had an under-cutter-blade as the primary digging tool and both used a digging chain with mechanical or hydraulic agitation to lift the roots out of the soil and to shake the soil from the roots. These harvesters dropped the roots onto the soil surface. Manual collection was then required. Harvesters with additional features for soil, stone and trash removal and automatic truck loading was available from both manufacturers. The depressed ginseng market made used harvesters readily available, and these would cost about $ 10,000. The design and construction of the Ginsenger and the Ginseng Digger indicated that these harvesters may require modification to dig sufficiently deep for Saskatchewan Echinacea growers.

A Weening Brothers Manufacturing Ginsenger and a Bartschi FOBRO Super HD Lifter/Shaker were rented and tested at Blue Hills Herb Farm, Inc.. The test results continue to be analysed but some preliminary observations can be reported. Both harvesters were capable of digging to a depth of 350 mm (14"). In sandy soil both harvesters successfully lifted the roots onto the soil surface. In clay soil both harvesters were less successful in lifting the roots from the soil. The clay soil broke into large clods and neither harvester could break the large clods. Preliminary results indicate existing root harvesters will harvest E. angustifolia under some conditions in Saskatchewan.